



BASIC GAS

CHLORINATION WORKSHOP

MANUAL

Training and Licensing Branch

ONTARIO WATER RESOURCES COMMISSION

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BASIC GAS
CHLORINATION WORKSHOP
MANUAL

*Training and Licensing Branch,
Ontario Water Resources Commission,
135 St. Clair Avenue West,
Toronto 7, Ontario.*

1st edition - November, 1971

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Jacques L. Bourque
J. L. Bourque,
Curriculum Development
and Training Officer.

INTRODUCTION

The initial Basic Gas Chlorination Workshop manual was produced solely for the use of operators attending the first Basic Gas Chlorination Workshop which was given November 15-19, 1971. To produce the present manual it was found necessary to revise the initial manual in order to present the material in a more comprehensive manner. It is hoped that this manual will be used by operators as a home study manual, especially by those who may not be able to attend one of the workshops.

The workshops, given at the OWRC Laboratories Lecture Hall and Wallace & Tiernan Inc., are five days in length. Approximately half a day is devoted to theory; half a day to lab testing; one day to safety and three days to equipment. It is evident that the emphasis in this workshop is on the proper operation and preventative maintenance of gas chlorination equipment. Workshops dealing with hypochlorination equipment (feeding solutions of sodium or calcium hypochlorite) and the related basic theory, safety and testing are being planned and will be offered in the future. It is also the intention of the Training and Licensing Branch to develop an advanced chlorination course which will cover chlorination theory and application from the operations point of view with the senior operator and superintendent in mind.

The principal reason for developing a gas chlorination workshop as the first of a series of workshops and courses on specific subject areas is the great importance of chlorination in maintaining a desirable water quality at wastewater and, more particularly, at water treatment plants. It was found that many operators have a fear of chlorine gas, and as a result they are reluctant to undertake the necessary preventative


maintenance procedures to keep the chlorination equipment in proper operating order. As a consequence, there have been interruptions in the application of chlorine for the treatment of water and wastewater at treatment plants. It is the expressed desire of this branch that operators taking part in one of these workshops will gain the necessary knowledge and skill in safety and preventative (some corrective) maintenance procedures. Of course, basic theory and chlorine residual testing will be covered as well.

All the *Behavioral or Performance Objectives* of the workshop have been summarized under Topic O, *Behavioral Objectives to Training (BOAT)*. The *SUBJECT* matter is broken into sections on *THEORY, SAFETY, EQUIPMENT* and *LAB TESTS*. An *APPENDIX* is also included.

The subject matter of each section is further broken down into *TOPICS*. Topics 1-4 are on Theory; topics 5-10 on Safety; topics 11-17 on Equipment; and topics 18-20 on Lab Tests. The appendix will include OWRC Bulletin 65-W-4 (appendix A); the Department of Labour Data Sheet on Storage and Use of Chlorine (appendix B); Personal Hygiene (appendix C); and General Lab Safety Instructions (appendix D).

The objectives are clearly indicated at the beginning of each topic, and tell the operator exactly what he should know or do in relation to that topic. It also tells the instructor what he will be teaching. The operator is expected to reach a minimum *LEVEL OF COMPETENCE* of 70% for the workshop. Testing will be done in one of two ways, and will depend on the particular objectives. There will be written tests, and there will also be practical, or hands-on testing with actual equipment available for the latter.

The Training and Licensing Branch would welcome comments.


A.B. Redekopp, Supervisor,
Training and Licensing Branch.

BEHAVIORAL OBJECTIVE APPROACH TO TRAINING (BOAT)

GENERAL

The behavioral or performance objectives are designed to tell the operator, or trainee, what he will have to know and what he will have to do for successful completion of the workshop. At the same time, it tells the instructor what he will have to teach, describe or demonstrate so the trainee will reach his goal (and not what he would like to teach).

This approach to teaching is based on the Behavioral Objective Approach to Training (BOAT).

WHAT IS BOAT?

BOAT is a method of training which states in clear and concise terms what the performance of a trainee will be upon completion of a learning period, such as a workshop. The objective, or objectives, are clearly stated at the beginning of each topic, so both the trainee and instructor know what must be done. To verify successful completion, tests are given under conditions as similar as possible to actual on-the-job working conditions. If the test requires an actual "hands-on" type of performance, the trainee will be tested accordingly. If, on the other hand, he must remember certain details, or be able to recognize certain operating conditions again he will be tested accordingly.

Objectives serve other purposes as well: they enable the operator to determine how well he is doing on a particular topic, and they also enable the instructor to organize his time for maximum efficiency. In addition, the objectives serve to define the effectiveness of the instructor by determining whether the trainees are able to perform to a given level of competency.

Topic 3: Types of Chlorine Feed and Their Usage

Trainee will be able to:

1. identify the basic types of chlorine feed
2. describe their usage.

Topic 4: Control Systems

Trainee will be able to:

1. name the types of chlorine control systems
2. describe the chlorine control systems.

SUBJECT - SAFETY

Topic 5: Storage and Handling Chlorine Gas Cylinders (150 Lb. and One Ton)

Trainee will be able to describe and/or demonstrate the following:

1. handling and storage procedures for chlorine cylinders
2. connecting cylinders using clamp and adapter
3. connecting cylinders using threaded connections
4. opening the cylinder valve
5. using two or more cylinders
6. method of determining contents of cylinder
7. closing cylinder valve.

Topic 6: Operating Safety Instructions

Trainee will be able to describe and/or demonstrate operating safety instructions regarding the following:

1. chlorine exhaust fan
2. self-contained air pack
3. chlorine leaks
4. changing cylinders
5. yoke, adapter and clamp
6. removing green slime
7. renewing metal chlorine gas piping

Topic 7: Leak Detection and Remedies

Trainee will be able to describe and/or demonstrate the following:

1. safety procedures - leak detection
2. general rule to follow when leaks are encountered
3. types of leaks encountered - and their remedies.

Topic 8: Properties and Physiological Effects of Chlorine

Trainee will be able to:

1. define the following chlorine properties:
colour, density, expansion rate, solubility,
flamability and explosiveness;
2. recognize the potential hazards of chlorine
and its physiological effects.

Topic 9: First Aid Suggestions

Trainee will be able to demonstrate and/or describe the following suggested first aid procedures regarding chlorine:

1. removing patient from gas area
2. placing patient on back, elevate head and back
3. calling physician immediately
4. removing clothing contaminated with liquid chlorine
5. administering mixture of carbon dioxide and oxygen
6. giving milk in mild cases as a relief from throat irritation
7. administering artificial respiration
8. cleansing the eyes
9. cleansing the skin splashed with liquid chlorine.

Topic 10: Emergency Plan

Trainee will be able to

1. describe and/or demonstrate the emergency procedures to follow if there is a leak from a cylinder which cannot be stopped or repaired
2. contact the following person or persons:
 - a. his immediate supervisor
 - b. the Fire Department
 - c. the Police Department
 - d. the chlorine supplier
 - e. the Medical Officer of Health
 - f. the Ontario Water Resources Commission District Engineer, or Supervisor of Water Works.

SUBJECT - EQUIPMENT

Topic 11: Components

Trainee will be able to identify (orally or in writing) the principal components of the chlorination system.

The principal components are:

1. chlorine gas cylinder
2. chlorine weighing scales
3. flexible coils
4. chlorine manifold or header
5. chlorinator (including chlorinator valves)
6. water pressure regulator
7. booster pump
8. strainer preceding injector
9. valves (excluding chlorinator valves) cylinder, auxiliary, header, check, relief, pressure, reducing
10. evaporator
11. exhaust fan
12. safety devices (alarm system, rupture discs)
13. recording charts and pens
14. compressors.

Topic 12: Start-Up

Trainee will be able to:

1. demonstrate start-up of chlorination system
2. perform the following steps in proper sequence:
 - a. start vent fan
 - b. open water lines
 - c. check chlorinator vacuum
 - d. open cylinder and valves
 - e. check for leaks.

Topic 13: Normal Operation of Systems

Trainee will describe the normal operation of the following chlorination systems:

1. Wallace & Tiernan (W&T) variable vacuum chlorinator

2. Advance chlorinator
3. Wallace & Tiernan (W&T) bell jar chlorinator
4. BIF Industries chlorine feeder
5. Fischer & Porter gas dispenser.

Topic 14: Shut-Down

Trainee will be able to:

1. demonstrate shut-down of chlorination system
2. perform the following steps in proper sequence:
 - a. start vent fan
 - b. shut off cylinder(s)
 - c. check chlorine pressure
 - d. shut chlorine line valves
 - e. shut water valves.

Topic 15: Maintenance

Trainee will be able to:

1. recognize mechanical malfunctions of:
2. describe immediate and/or long-term operational adjustments for:
3. name most probable component(s) needing repair or replacement for:
4. list in order of probability, from highest to lowest, most probable causes of malfunction for:
 - a. vent fan
 - b. injector
 - c. rate controller
 - d. rotameter
 - e. pressure and vacuum gauges
 - f. evaporator
 - g. alarm system
 - h. recording instrument
5. describe a daily, weekly and annual maintenance schedule.

Topic 16: Trouble-Shooting

Trainee will be able to describe and/or demonstrate trouble-shooting chlorinators with a manometer and vacuum gauge by determining the following:

- a. chlorinator symptoms
- b. what is probably wrong
- c. what to measure
- d. how to measure

- e. typical numerical values for proper operation
- f. auxiliary checks
- g. how to remedy symptoms.

Topic 17: Chlorine Residual Analyzer and Controller (Optional)

Trainee will be able to:

- 1. describe the basic principles of the chlorine residual analyzer and controller
- 2. recognize the most common maintenance problems of residual analyzer recorders and residual controllers.

SUBJECT - LABORATORY

Topic 18: DPD Method

For the DPD Method, trainee will be able to:

- 1. determine the reagents required for the Nessleriser or Comparator
- 2. determine the ranges covered by the Nessleriser and Comparator discs
- 3. demonstrate the procedure to follow using the Nessleriser and Comparator.

Topic 19: Orthotolidene Test

Trainee will be able to describe and/or demonstrate:

- 1. the orthotolidene method for total chlorine residual
- 2. the orthotolidene flash test method for estimating free chlorine.

Topic 20: Amperometric Titration Method (Optional)

Trainee will be able to describe and/or demonstrate the following:

- 1. principle of titration
- 2. titration - principle of operation
- 3. method to determine free chlorine residual
- 4. method to determine combined chlorine residual
- 5. method to determine total chlorine residual
- 6. interpretation of results
- 7. monochloramine and dichloramine differentiation.

SUBJECT:
CHLORINATION THEORY

TOPIC: 1
PURPOSES OF CHLORINATION
AND QUALITY CONTROL

OBJECTIVES:

Trainee will be able to describe
and/or list:

1. The different purposes of
chlorination,
2. General quality considerations,
3. OWRC chlorination objectives.

PRINCIPAL PURPOSE

The principal purpose of chlorination is *DISINFECTION* - killing bacteria, viruses harmful to man. In the killing of the bacteria and viruses the chlorine does not do it directly but rather primarily by the formation of hypochlorous acid (free residual chlorination) which is formed when the chlorine gas and the water are mixed together in the chlorinator. At the same time an equal amount of hydrochloric acid is produced which reacts with the alkalinity in the water and is of no consequence in the disinfection of water. In case of very high chlorine dosages the acid can seriously reduce the pH and cause corrosion.

OTHER PURPOSES OF CHLORINATION include

Control of certain taste and odour problems when free or combined residual chlorination is practiced; for example, oxidation of iron and hydrogen sulphide.

Oxidation of manganese, nitrites, and ammonia, or the destruction of phenols and the removal of algae and slime growth

can be accomplished by free residual chlorination.

If too little chlorine is added, the taste and odour problems may become pronounced.

When chlorine is added to water for the purpose of disinfection, it also reacts with both inorganic and organic materials that might be present. These reactions complicate the disinfection process because the chlorine demand of these materials must be satisfied as well as those associated with the disinfection reactions.

CONTACT TIME

The purpose of contact time is to allow *complete reaction* of the chlorine with the foreign matter in the water and also to kill bacteria and viruses present in the water supply. *A minimum contact time of 30 minutes is recommended.*

Always add chlorine at a point where complete mixing will occur.

GENERAL WATER QUALITY CONSIDERATIONS

A general statement pertaining to the chlorination of various water supplies cannot be made. Each must be considered on the basis of the degree of chemical and bacteriological pollution existing in the individual water supply.

Considering a dosage of 1 ppm chlorine applied to a chemically clean water (free of ammonia or protein substances) that contains some bacteria, it has been found that hypochlorous acid (the most potent chlorine compound, free residual) remains as such and would kill all the bacteria in seconds. On the other hand the same dosage of 1 ppm chlorine applied to chemically dirty water like the Grand River (containing free ammonia and protein substances from sewage, industrial waste, algae and land drainage) would show that the hypochlorous acid would rapidly react with the

ammonia and protein substances for form chloramines. These chloramines or combined residual chlorination can take hours to kill the same number of bacteria that are killed in seconds by the hypochlorous acid or (free residual chlorination). Furthermore, the chlorine can react with other materials in the water such as iron or non-protein organic matter and be completely consumed without producing any type of chlorine residual and has no ability to disinfect.

Therefore the magnitude and type of chlorine residual must be governed by the following:

- (a) type of residual required,
- (b) degree of chemical and bacterial pollution,
- (c) period of contact available in the plant from application of chlorine to the first consumer.

OWRC CHLORINATION OBJECTIVES

The OWRC has set up minimum objectives (see OWRC Bulletin 65-W-4 in appendix) for chlorination of public water supplies. It should be understood that these objectives are set up on the broadest possible concept to protect the maximum number of consumers at any one time. It should also be understood that the OWRC is aware that there will be certain instances where the contact time and chemical and bacteriological pollution are such that these minimum objectives will have to be exceeded in water plant operating practice and consequently a higher residual may have to be used.

An operator can be abiding by the guidelines in meeting the minimum objectives but still produce a water contaminated with coliform bacteria. In such cases public health is in danger and immediate changes in the chlorination program must be instituted. Such changes may include:

- (a) increase in chlorine residual,
- (b) a change in the type of residual,

- (c) change in the point or points of application,
- (d) increase in the contact time between point of application and the first consumer.

The measure of success of all of these changes will be judged on the basis of the bacteriological test of the water leaving the plant. All of the above concepts are accepted and adhered to on a world-wide basis by organizations similar to the OWRC.

The waterworks business is an industry producing a saleable potable product. As such certain quality control measures are required. One of these is the chlorine residual analyser and recorder. The operator should ensure that this equipment is kept in proper operating order. The record of chlorine residual provides the operator with positive proof of performance.

As a minimum requirement the operator should check the chlorine residual once each shift and record the results. The residual should be maintained at or above the minimum required for the plant. These requirements are set by the OWRC District Engineer (Sanitary Engineering Division) who uses OWRC Bulletin 65-W-4 as a guide.

pH AND ITS EFFECT ON CHLORINATION

pH is an indication of the acidity or alkalinity of a water. It can be *lowered* to corrosive levels by the application of chlorine, alum and other coagulants. In some cases the pH of the raw water may be too low to start with. Regardless of the cause of low pH it should be corrected to a suitable range to prevent corrosion by the addition of an appropriate alkali prior to the water going to the distribution system. *It must be realized that all chlorine compounds are most effective in bacteria and virus destruction at low pH and therefore any pH correction upwards (above 7.5) should be done after the chlorine has done its work.*

IMPORTANCE OF TURBIDITY REMOVAL

In the chlorination of water, no mention is made of the effects of turbidity since it is assumed that the water meets the turbidity requirements of 1 J.T.U. maximum. It should be pointed out, however, that *bacteria can be concealed within the turbidity particles and be immune to the effects of chlorination.* In modern treatment plants we think of turbidity removal in terms of improving the appearance of the water and preventing the accumulation of mud in the distribution system but probably forget the even more important point that it eliminates "chance bacteria contamination."

GENERAL WASTE WATER QUALITY CONSIDERATIONS

The most important application of chlorine in the treatment of sewage is for disinfection. The bacteria in sewage may be broadly classified as of two types - useful and harmful. The useful types are the organisms which live on dead or decaying organic matter. The harmful types are the pathogens, organisms which cause disease, such as typhoid fever, gastro-enterites, cholera and dysentery. The principal purpose of chlorination is to destroy these harmful bacteria.

In sewage treatment plants chlorine may be applied to the raw sewage (in a sewer, pump well or channel at the plant) and/or the treated effluent. In addition to the principal purpose of disinfection the application of chlorine to the influent will serve to control odour throughout the plant. It should be borne in mind that chlorine is a surface-active agent. This means that the bacteria which have hidden themselves within a dirt particle will not be killed by the chlorine. For this reason chlorine for disinfection purposes should be added at a point after solids removal (effluent of sedimentation tanks). In addition the chlorine demand will be lower after solids removal requiring a lower chlorine dosage to accomplish the required total chlorine residual of 0.5 ppm after a 15 minute contact period. For the purpose of providing the required minimum contact period, a chlorine contact chamber (properly baffled) is normally used.

NOTES:

SUBJECT:
CHLORINATION THEORY

TOPIC: 2
DEFINITIONS

OBJECTIVES:

Trainee will be able to define the following terms:

1. Chlorination
2. Superchlorination
3. Dechlorination
4. Hypochlorination
5. Gas chlorination
6. Prechlorination
7. Postchlorination
8. Marginal chlorination
9. Breakpoint "
10. Disinfection
11. Sterilization
12. Chlorine demand
13. Residual chlorine
14. Free residual chlorine
15. Combined residual chlorine
16. Total residual chlorine
17. Free residual chlorination
18. Chloramines
19. Oxidation
20. Parts per million

DEFINITIONS

1. CHLORINATION

The application of a chlorine solution to a water supply or wastewater stream for the principal purpose of reducing population of harmful disease causing bacteria to an acceptable level.

Refer to OWRC Bulletin 65-W-4 (see appendix) for details.

2. SUPERCHLORINATION

The application of chlorine dosages greatly in excess of those normally used for disinfection purposes.

3. DECHLORINATION

A deliberate treatment of water to remove excess residual chlorine. Normally done prior to sending water out into system.

4. HYPOCHLORINATION

The addition of hypochlorites, such as sodium or calcium hypochlorite, to the water or wastewater to be treated. It is added in solution form usually by means of a diaphragm positive displacement pump. Used where chlorine requirement is small or where gas cannot be fed (safety, lack of water pressure).

5. GAS CHLORINATION

Chlorine gas mixed with water to form solution to treat water or wastewater.

6. PRECHLORINATION

The application of chlorine to a water supply before any other treatment.

7. POSTCHLORINATION

The addition of chlorine to the water after all other treatments.

8. MARGINAL CHLORINATION

The addition of chlorine to water or wastewater to produce a total chlorine residual in the range of 0.2 to 0.5 mg/l.

9. BREAKPOINT CHLORINATION

Point at which near complete oxidation of chloramines and other chlorine combination is reached. Any residual beyond breakpoint is mostly free available chlorine.

10. DISINFECTION

The reduction of bacterial populations to a safe level.

There are many disinfectants: chlorine, bromine, iodine (not fluorine); costs are too high to use iodine or bromine.

11. STERILIZATION

Total destruction of bacterial populations.

We never sterilize in the water or wastewater industry.

12. CHLORINE DEMAND

The difference between the amount of chlorine added to water or wastewater and the amount of chlorine residual remaining at the end of a specified contact period. The chlorine demand for any given water varies with the amount of chlorine applied, time of contact, temperature, pH and the amount of chemical and organic contaminants in the water.

13. CHLORINE RESIDUAL

Chlorine remaining in water or wastewater at the end of a specified contact period as combined or free chlorine.

14. FREE CHLORINE RESIDUAL

Amount of chlorine available as dissolved gas, hypochlorous acid, or hypochlorite ion that is not combined with an amine or other organic compound. It is 25 times as powerful as combined chlorine residual.

15. COMBINED CHLORINE RESIDUAL

The chlorine in water in chemical combination with ammonia or other nitrogenous compounds which modify its rate of bactericidal action.

16. TOTAL CHLORINE RESIDUAL

Summation of free chlorine residual and combined residual.

17. FREE RESIDUAL CHLORINATION

The addition of chlorine to water or wastewater until most of the requirements of ammonia and proteins are

met plus a slight excess. This excess will then be in the form of hypochlorous acid which will attack and destroy the chlorinated ammonia and protein substances formed by the initial dose of chlorine. All the resulting residual will consist of 90% or better hypochlorous acid.

Free residual chlorination is particularly useful where large numbers of bacteria must be killed in a chemically contaminated water. It has been clearly demonstrated that it will also inactivate the viruses. This system of chlorination is also noted for colour removal and is effective for the reduction of taste and odours in a raw water supply.

18. CHLORAMINES

Compounds of organic or inorganic nitrogen and chlorine. The reaction of free available chlorine with ammonia and many organic amines to form chloramines, including monochloramine and dichloramine.

19. OXIDATION

A breakdown of complex organic compounds which on some occasions are found in water supplies and contribute to taste and odour problems. Oxidation produces compounds that are less liable to produce taste and odour.

20. PARTS PER MILLION

Parts per million (ppm) and milligrams per litre (mg/l) are commonly used terms for expressing concentration in water and wastewater operations. It is a measure of a very small amount of a substance in a very large amount of water.

$$1 \text{ mg/l} = 1 \text{ ppm}$$

In chlorination practice an operator should be able to calculate the average chlorine dosage in ppm given the amount of chlorine used during a given period of time and the amount of water chlorinated during the same period of time. This period of time may be the instantaneous chlorine reading on

the chlorinator and the instantaneous water meter reading or as is more frequently the case the amount of chlorine fed for a 24 hour period (based on weigh scale readings) and the water pumpage during the same 24 hour period.

Example: At 8:00 am on Tuesday the chlorine cylinder scale indicated 232 lbs and the water meter read 78,343,000 gals.

At 8:00 am on Wednesday the chlorine cylinder scale indicated 169 lbs and the water meter read 85,763,000 gals. What was the average chlorine dosage in ppm during this 24 hour period?

Chlorine used during 24 hour period = $232 - 169 = 63$ lbs.

Water treated during same period

$85,763,000 - 78,343,000 = 7,420,000$ gals.

Average chlorine dosage:

$$\frac{63 \text{ lbs (chlorine)} \times 1,000,000}{7,420,000 \text{ gals (water)} \times 10 \text{ (convert. gals to lbs)}} = 0.85 \text{ ppm}$$

A simple formula to remember:

$\frac{A}{B \times 10} \times 1,000,000 = \text{ppm}$

Replace A with No. of lbs of chlorine

Replace B with No. of Imp. gals of water

Remember use the same time period for both.

NOTES

SUBJECT:

CHLORINATION THEORY

TOPIC: 3

TYPES OF CHLORINE FEED
AND THEIR USAGE

OBJECTIVES:

Trainee will be able to:

1. Identify the basic types of chlorine feed,
2. Describe their usage.

TYPES OF CHLORINE FEED

The three basic types of chlorine feed (or chlorinators) are:

1. Dry (direct) feed gas chlorinators
2. Solution feed gas chlorinators
3. Hypochlorinators - chlorine compounds

USAGE

1. Dry (direct) feed gas chlorinators are used to apply dry chlorine gas to sewage.

They are used only where water under pressure is not available.

Their usage requires care in selecting the point of application.

2. Solution feed gas chlorinators mix an auxiliary supply of water with chlorine gas.

The mixture or solution is then applied to the water or the sewage to be treated.

Vacuum-type chlorinators are the most preferred.

3. Hypochlorinators - chlorine compounds, are used for relatively low flows, where the chlorine requirement is small or where chlorine gas cannot be fed for safety reasons, or due to a lack of water pressure.

Installation costs are lower than for gas chlorinators, but operating costs are higher.

NOTES

SUBJECT:
CHLORINATION THEORY

TOPIC: 4
CONTROL SYSTEMS

OBJECTIVES:

Trainee will be able to:

1. Name the types of chlorine control systems,
2. Describe the chlorine control systems.

TYPES OF CONTROL SYSTEMS

1. Manual system (totally fixed - run at one flow)
2. Flow proportional or open loop control
3. Direct residual or close loop control
4. Compound loop control

1. MANUAL SYSTEM

- (a) Rate of feed varied by hand
- (b) Only suitable at points where flow of sewage or water to be treated is constant, or flow is varied by hand, at which time chlorination feed can be set.

2. FLOW PROPORTIONAL OR OPEN LOOP CONTROL (See Figure 4-2 and 4-3)

- (a) Adjustment made in accordance with command signal from flow or pump
Response is ASSUMED to be correct
- (b) Any signal from primary measuring device (orifice, venturi, etc.) can be fed directly or converted to proper form by a transducer so as to facilitate electric or pneumatic positioning of chlorinator control units.

3. DIRECT RESIDUAL OR CLOSED LOOP CONTROL (See Figure 4-1)

- (a) sample is continuously withdrawn downstream of point of chlorination and analyzed
- (b) recorder compares measured residual with desired residual and determines if it is necessary to increase or decrease chlorine feed rate. It then sends a signal to the chlorinator control device
- (c) Types of Signals:
 - (i) electric or pneumatic signal
 - (ii) chlorinator control unit
 - (iii) vacuum signal to differential regulator

NOTE:

Why is it a closed loop?

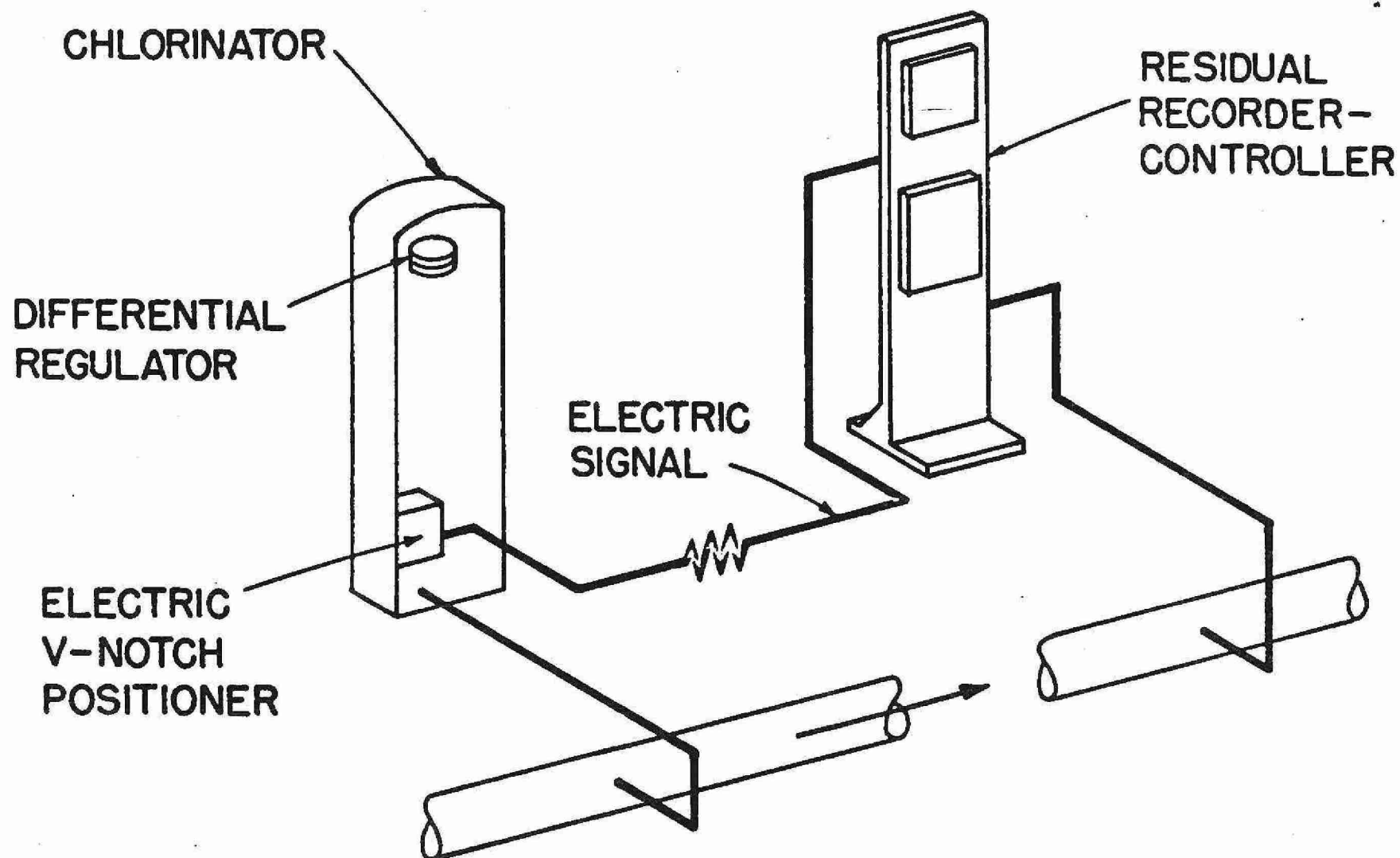
Measurement of end result is made and information is fed back to control devices for comparison with control set point.

4. COMPOUND LOOP CONTROL (See Figure 4-4)

- (a) a combination of open loop with closed loop system
- (b) when flow increases, chlorinator adds the mathematically correct amount of chlorine to maintain the present dosage level. Downstream a sample is withdrawn and analyzed to determine if chlorine demand has changed. If so, information is relayed back to the chlorinator and correction is made.

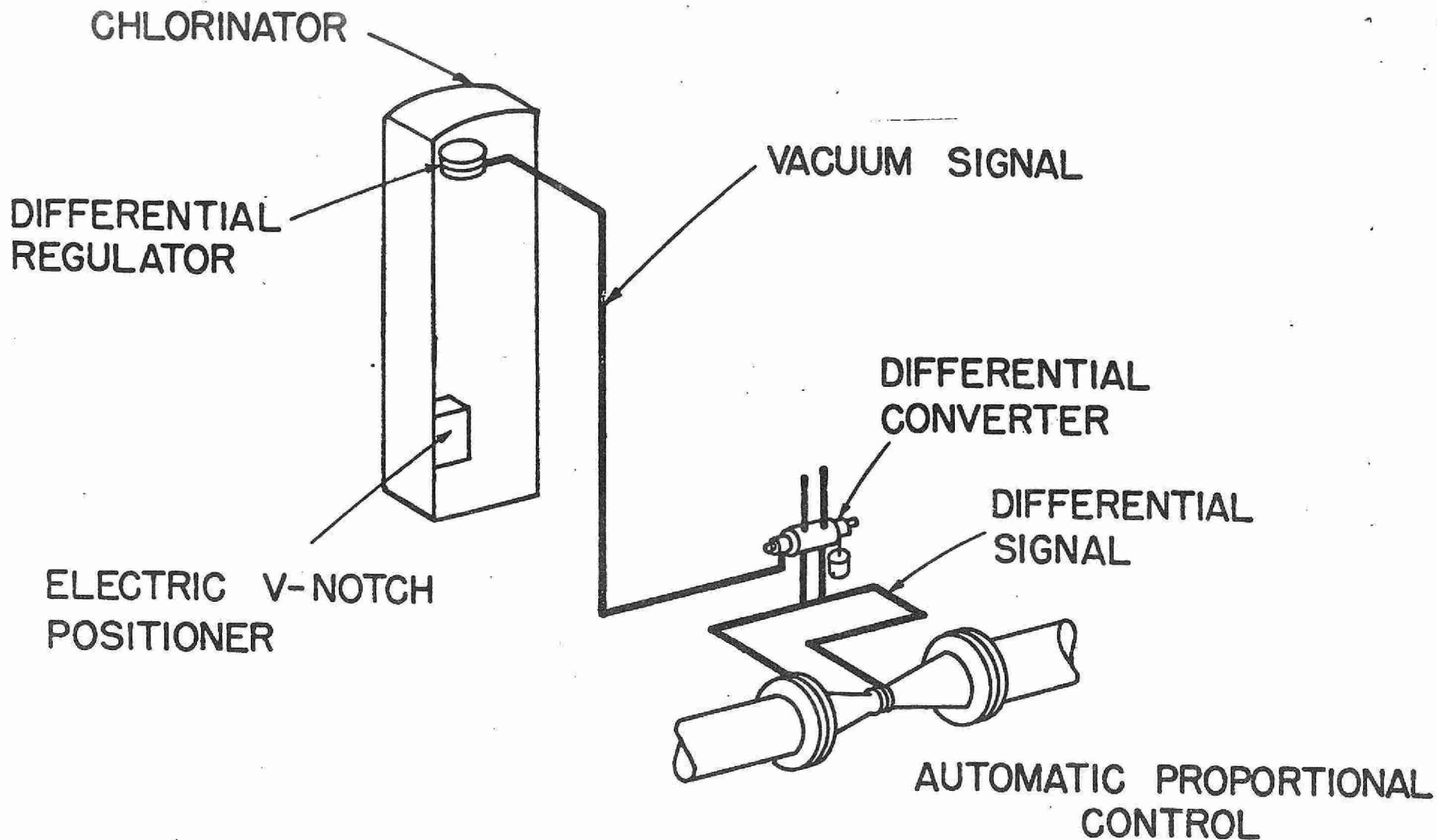
NOTE:

1. *When flow remains constant, but chlorine requirements do not, direct residual control is applicable*
2. *conversely, when flow varies and chlorine requirements remain constant, flow proportional or open loop chlorination control is used*
3. *when both flow and chlorine requirements may vary, compound loop chlorination control is used to maintain desired residual of chlorine in water.*

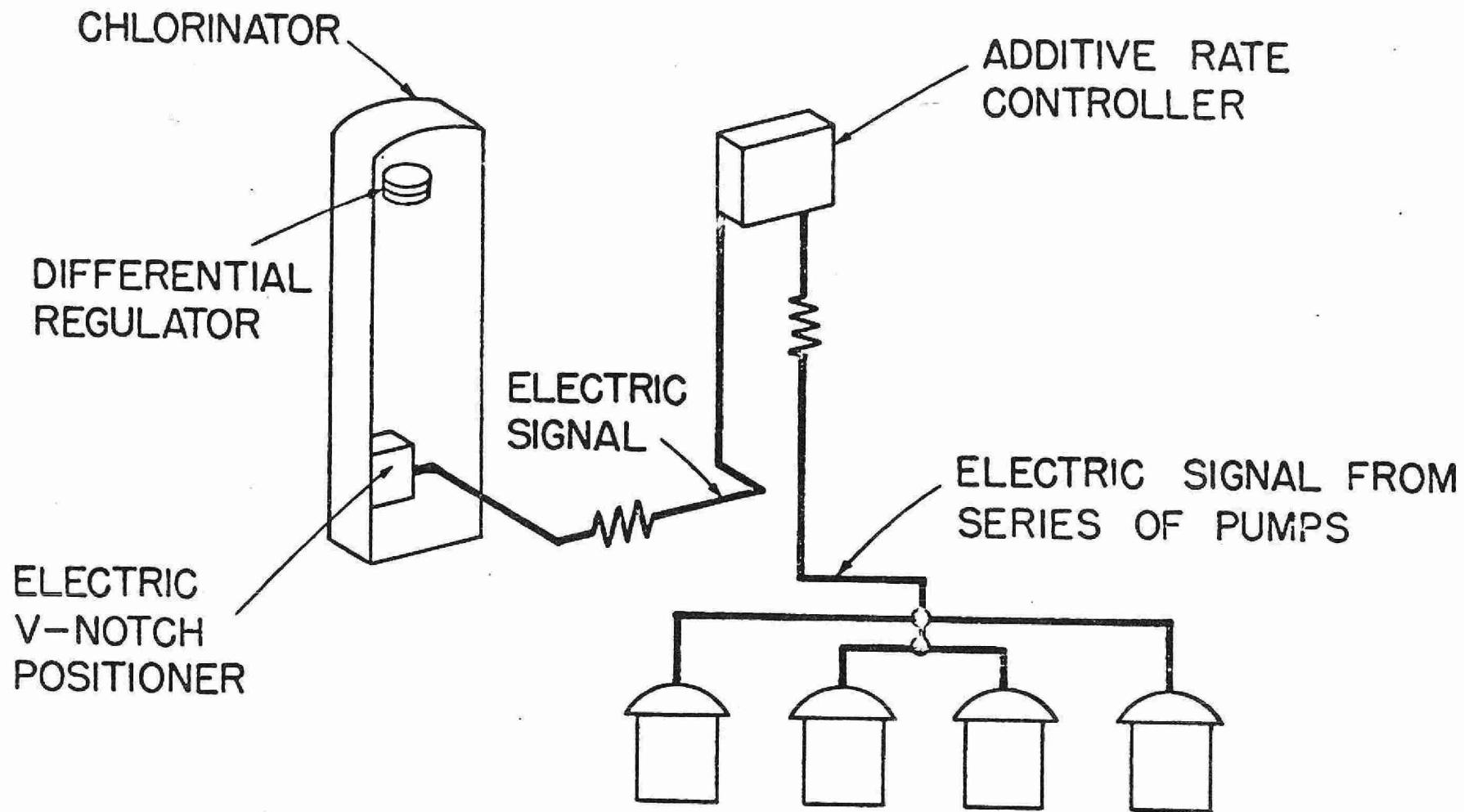


**DIRECT RESIDUAL OR CLOSED-LOOP
CONTROL CHLORINATION**

FIG. 4-1

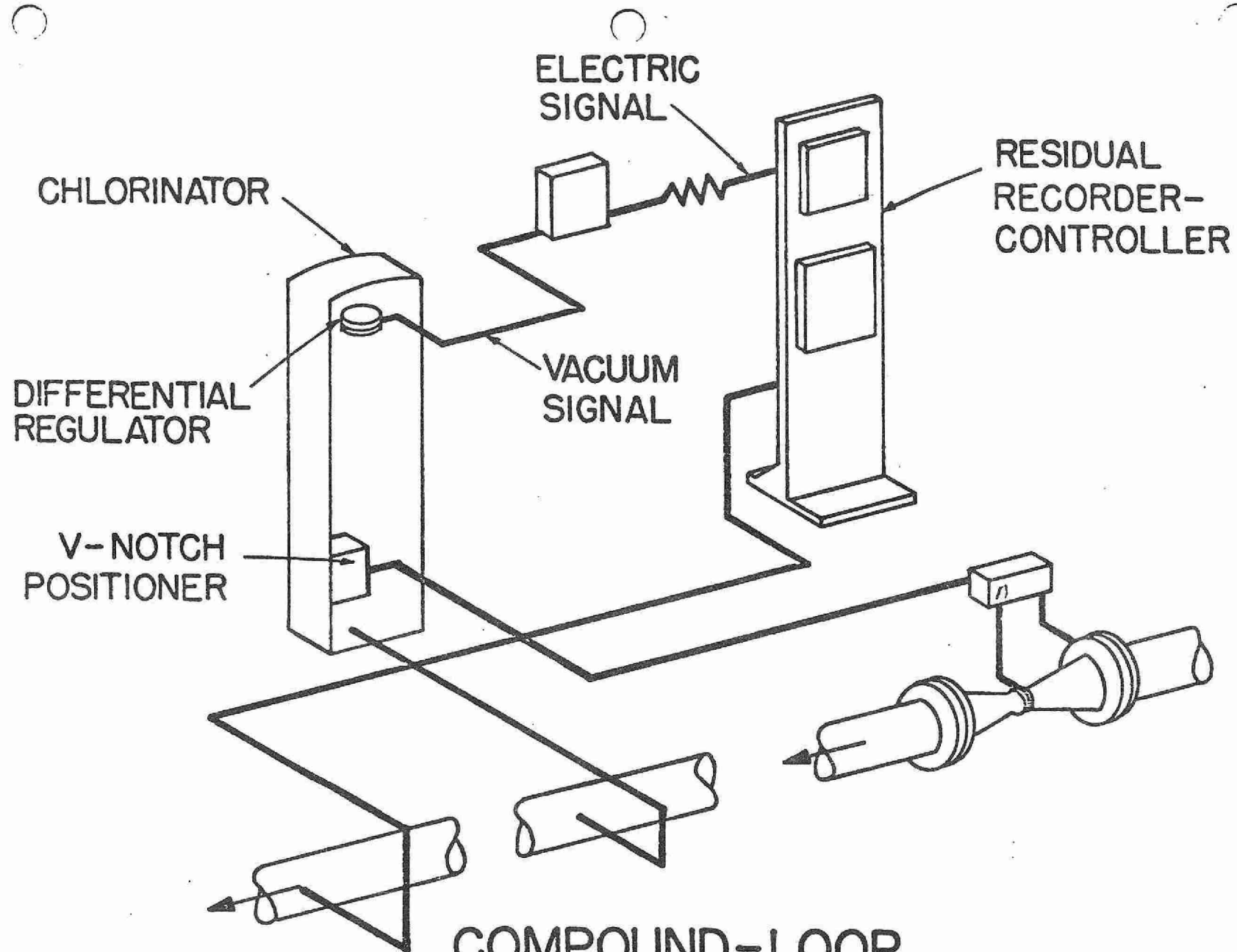


OPEN-LOOP CONTROL
CHLORINATION
FIG. 4-2



OPEN-LOOP CONTROL CHLORINATION

FIG. 4-3



COMPOUND-LOOP
CONTROL CHLORINATION
FIG. 4-4

Courtesy Wallace & Tiernan

NOTES:

NOTES:

SUBJECT:

CHLORINATION SAFETY

TOPIC: 5

STORAGE AND HANDLING CHLORINE
GAS CYLINDERS (150 LB. AND
ONE TON)

OBJECTIVES:

Trainee will be able to describe and/or demonstrate the following:

1. Handling and storage procedures for chlorine cylinders
2. Connecting cylinders using clamp and adapter
3. Connecting cylinders using threaded connections
4. Opening the cylinder valve
5. Using two or more cylinders
6. Method of determining contents of cylinder
7. Closing cylinder valve.

GENERAL

Chlorine is shipped in three types of containers, 150 lb. cylinders (the most familiar), ton containers and tank cars. The contents of any of these consist of a liquid phase and a gaseous phase. (See figure 5-1 and 5-7).

150 LB. CYLINDERS - HANDLING

When unloading and moving full 150 lb. cylinders do not allow them to be dropped from the truck. Prevent them from falling over or against each other.

When moving cylinders, it is recommended that a light three-wheeled hand truck with rubber tires be used. This hand truck should have a clamping arrangement or safety chain at least two-thirds of the way up the cylinder.

With experienced personnel, a cylinder can be safely moved by rolling it on its bottom edge. When rolling a cylinder in this manner, care should be exercised that it does not get out of control and fall, and that the protective bonnet is not allowed to turn loose.

When handling chlorine cylinders, the protective bonnet should be in position and should not be removed until the cylinder is to be connected to the chlorinating system. The same care should be used in handling full and empty cylinders. Use chlorine cylinders only for transporting and storing chlorine.

When it is necessary to lift a cylinder and an elevator is not available, a crane or hoist with a special cradle should be used. *Chains, rope slings and magnetic devices should never be used. Never lift a cylinder by means of the valve protective bonnet* because the hood is not designed to carry the weight of the cylinder.

150 LB. CYLINDERS - STORAGE

Chlorine cylinders should be stored upright and arranged so that any cylinder can be removed with a minimum handling of the other cylinders. Storage space should be well ventilated, readily accessible and preferably at normal room temperature.

Cylinders should *NOT* be stored:

1. Near combustible or flammable materials such as oil, gasoline and waste;
2. On an uneven floor or one covered with debris;
3. Near the inlet of a ventilating or an air-conditioning unit;
4. In sub-surface locations;
5. Near an elevator shaft;
6. Adjacent to any source of direct heat such as a furnace, heating element or radiator.

CHLORINE CYLINDERS

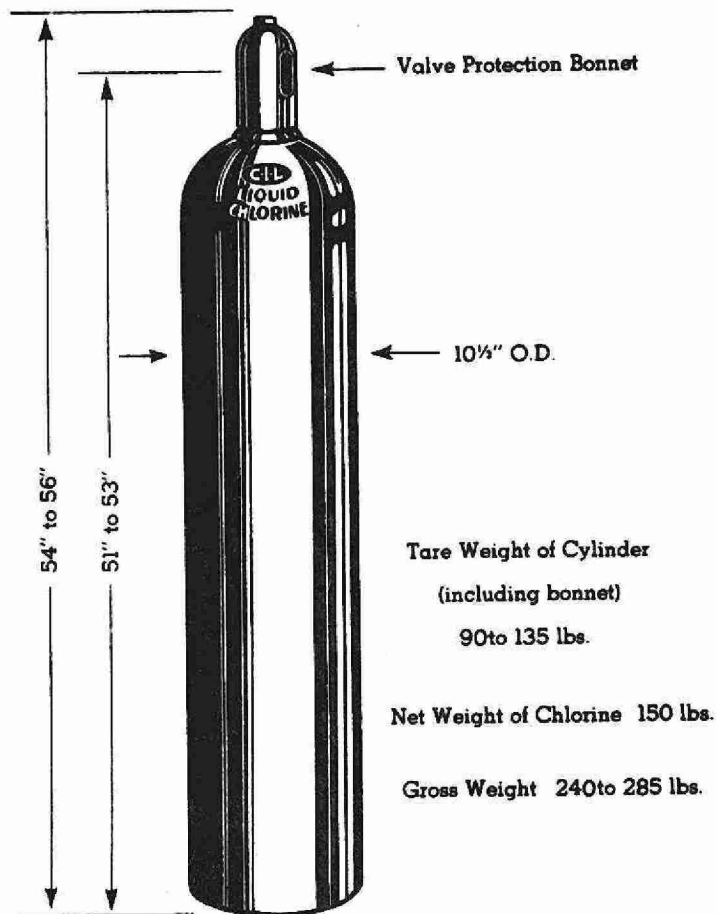


FIG 5-1 Chlorine cylinder.

Chlorine cylinders are of seamless steel construction and each is equipped with an approved type of valve. Every cylinder is fitted with a bonnet designed to protect the valve from impact due to knocking or dropping.

Letters and numbers are stamped on each cylinder indicating ownership, specification, cylinder number, tare weight and dates of hydrostatic tests. It is illegal to deface these markings in any way.

If it is impossible to avoid having cylinders stored or used on a floor below ground level then an adequate exhausting system should be provided for removing any escaped gas. Cylinders should be stored in a dry location as a damp atmosphere will corrode the threads of the protective bonnet making it difficult to remove.

Empty cylinders should be stored in one area, and full cylinders in another area. Cylinders must be stored in an upright position and prevented from falling over by using a safety chain anchored to the wall with a snap hook and placed around the outside of the cylinders.

150 LB. CYLINDERS - VALVE

The 150 lb. cylinders are equipped with a single Chlorine Institute standard cylinder valve which has a brass body and a Monel stem. There is a packing gland containing two rings of packing and a fusible plug. Valves are tested and reconditioned or renewed by the manufacturer after each trip. The fusible plug is made of poured metal and located on the side of the valve opposite the outlet. The fusible plug will melt at a temperature of 160°F, and its purpose is to release chlorine if pressure becomes excessive due to fire or over-heating. (Refer to Figure 5-2, 5-5 and 5-6).

The standard way of making a connection to this valve is with a yoke clamp, adapter and a small head gasket. These three items are supplied free by the chlorine suppliers (see Fig.5-3).

CONNECTING CYLINDERS USING CLAMP AND ADAPTER

The following steps should be followed when connecting a cylinder to the chlorinating system:

1. Secure the cylinder to a building column or solid upright support;
2. Remove the protective bonnet. If the cylinder has been exposed to the weather for a long time the threads at the base of the bonnet may have been corroded, in which case a few smart raps on opposite sides of the bonnet will loosen it so it can be unscrewed easily;

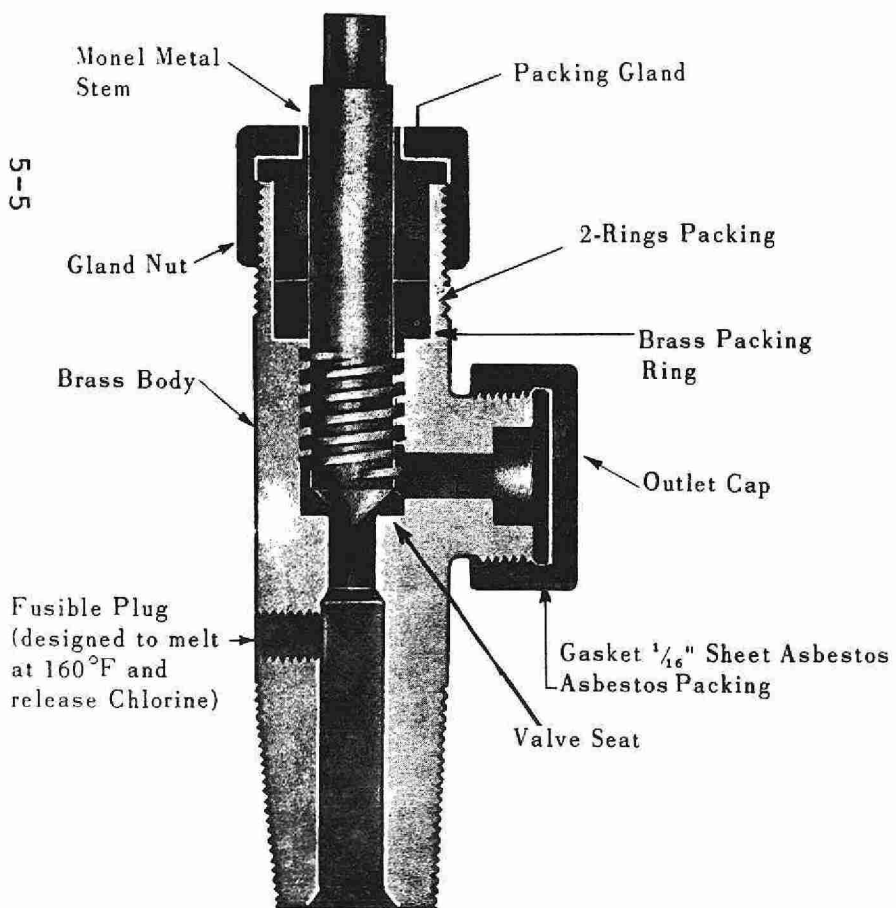


FIG 5-2 Chlorine Cylinder Valve

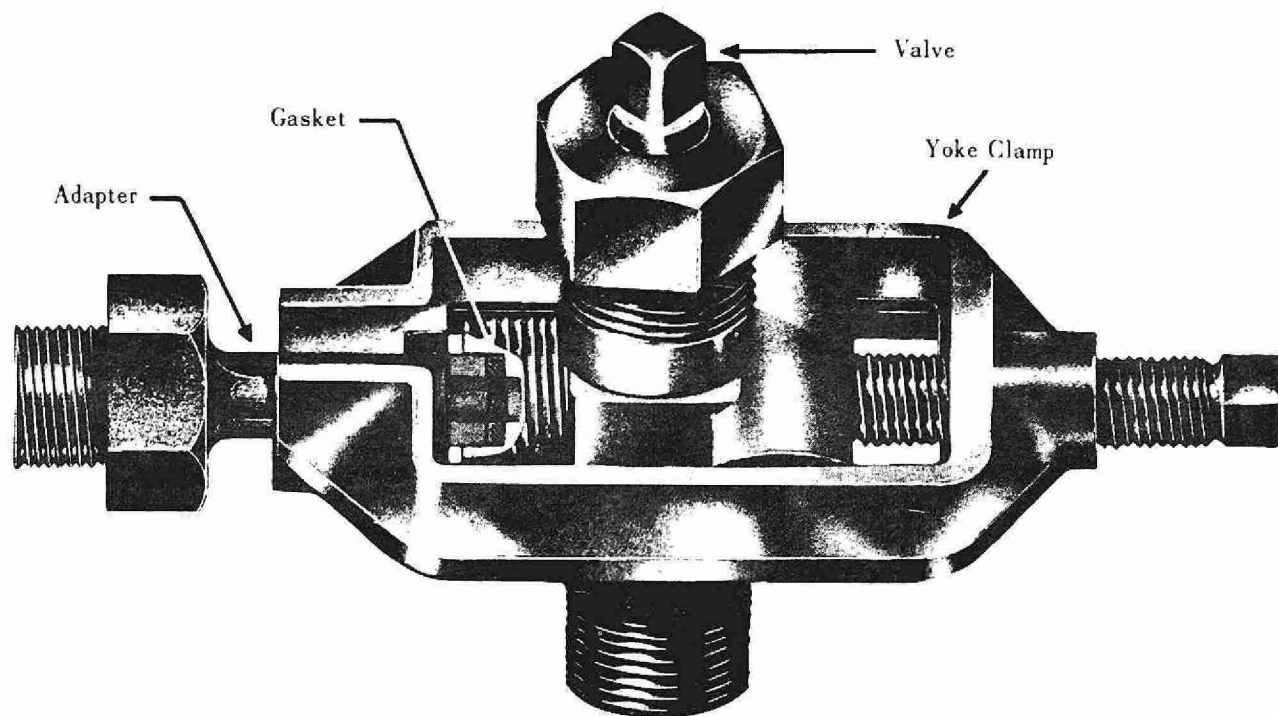


FIG 5-3 Valve Clamp and Adapter Assembly

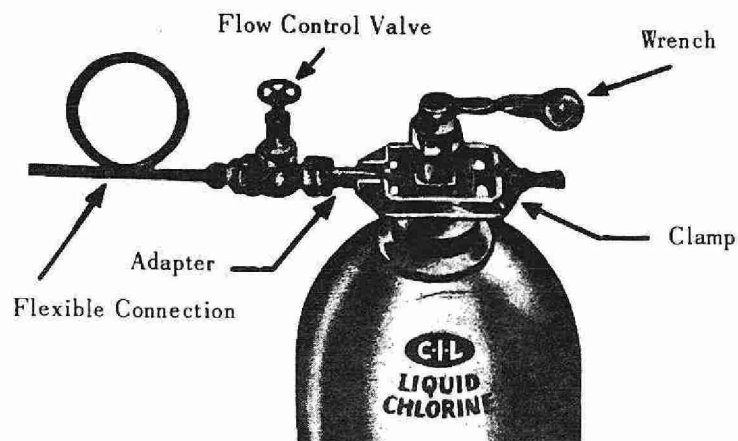
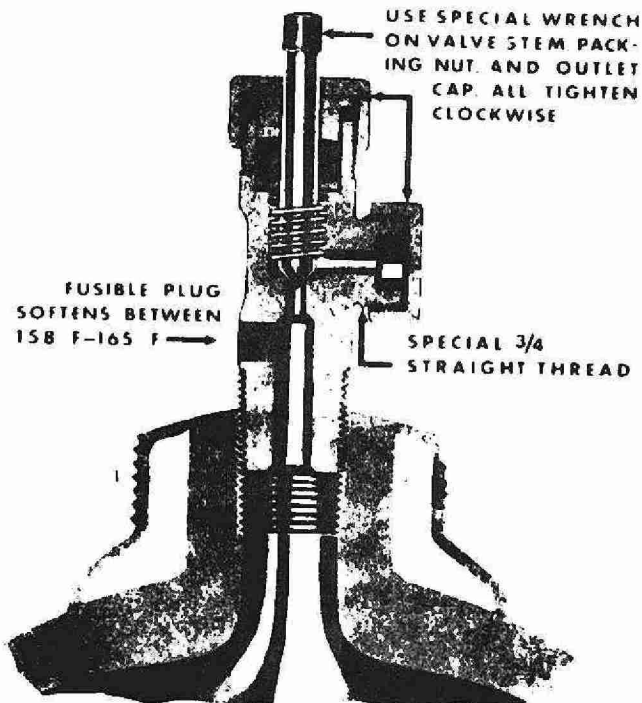
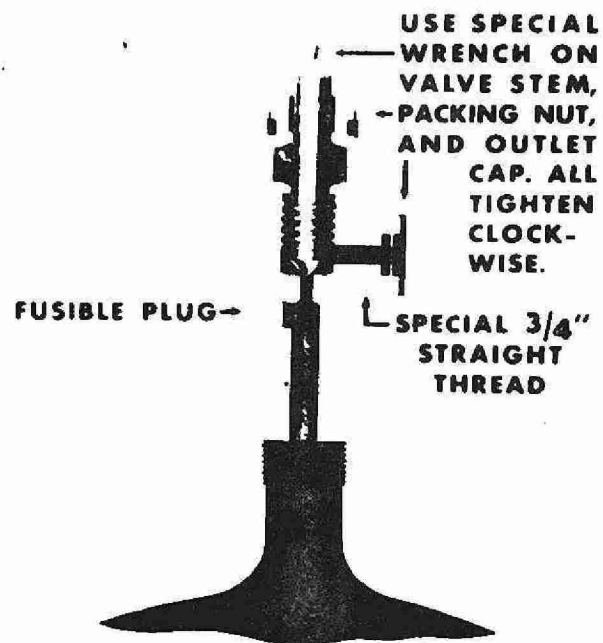


FIG 5-4 Cylinder Connected



**Fig 5-5 Chlorine Institute Standard Cylinder Valve
Poured Type Fusible Metal Plug**



**Fig 5-6 Chlorine Institute Standard Cylinder Valve
Screwed Type Fusible Metal Plug**

3. Remove the brass outlet cap and any foreign matter which may be in the valve outlet recess. Use a two-inch nail to clear out any old washer or pieces of lead thereof in outlet recess;
4. Place a new lead washer in the outlet recess;
5. Place the clamp over the valve.
Insert the adapter in the outlet recess and then, fitting the adapter in the clamp slot, tighten the clamp screw. Make sure that the end of the adapter seats firmly against the lead washer. Fig. 5-4 shows a cylinder connected to the coil.

NOTE: 150 lb. cylinders are almost always used in a vertical position for gas withdrawal.

DO NOT RE-USE LEAD WASHERS.

NEVER LIFT CYLINDER BY THE BONNET.

The protective hood on 150 lb. cylinders is screwed onto a threaded neck ring. Despite its appearance, the neck ring is actually not part of the cylinder, and is often not securely attached to the cylinder.

ALWAYS KEEP THE HOOD IN PLACE EXCEPT WHEN CYLINDER IS IN USE.

CONNECTING CYLINDER - USING THREADED CONNECTIONS

When making connections with piping having threaded couplings instead of the yoke type, two wrenches must be used, the large spanner for the coupling and the small spanner holding the squared area of the pipe itself at the coupling. Use the flat spanner or box-end wrenches supplied by the manufacturer for all chlorine cylinder pipe connections.

NOTE: Operators must wear protective goggles when working around chlorine equipment.

WEIGHING THE CYLINDER

The only reliable method of determining the contents of a cylinder is by weighing. The pressure in a cylinder depends

upon the temperature, not upon the amount of chlorine in the container. Where convenient, it is recommended that the cylinder should stand on a scale throughout the entire period of discharge. In any event, the only sure method of determining whether or not the cylinder is empty is to weigh it and check its weight against the tare stamped on the cylinder shoulder.

OPENING THE VALVES

The correct procedure for opening the cylinder valve is simple and easy. Place the wrench provided by the manufacturer on the valve stem, stand behind the cylinder valve outlet and while grasping the valve firmly with the left hand, hit the wrench a sharp blow in a counter-clockwise direction with the palm of the right hand. Do not pull or tug at the wrench as this may bend the stem, causing it to stick and, once opened, the valve may not close properly. Under no circumstances should an ill-fitting manufacturer's wrench or a pipe wrench be used since these wrenches will round the corners of the squared end of the valve stem. The manufacturer will gladly supply new wrenches on request. The use of large wrenches for opening stubborn valves should be avoided because, with the extra leverage obtained, there is danger of bending the valve stem. With a stubborn valve it is recommended that the normal opening procedure be followed with the exception that a small block of wood be held in the palm of the hand when striking the wrench.

Immediately after the valve has been opened and the flow of chlorine adjusted, tighten the gland nut on top of the valve with the hand. Cylinders are shipped from the manufacturer with the gland nut slack so that the valve packing will retain its elastic properties until required for use. If chlorine is allowed to escape through the gland, the packing becomes hard and unserviceable.

STARTING UP CHLORINATOR USING TWO OR MORE CYLINDERS

Turn on water to the chlorinator, make the necessary adjustments to the machine for operation when the gas is turned on.

Crack open the valve of the cylinder farthest from the chlorinator until approximately 40 lbs. of pressure is recorded on the pressure dial on the chlorinator.

SHUT OFF the cylinder valve and test for leaks. If there are no leaks, wait until the pressure on the gauge returns to zero.

Crack open the valve of the second cylinder and repeat the procedure used on the first cylinder and repeat until all cylinders being used have been tested. If a gas leak develops during the checkout of pipes and cylinders, the operator needs only to step out of the chlorine room and wait for the ventilating system to clear the gas from the room. The chlorine cylinder is already shut off and the chlorinator is using the gas in the piping.

At the beginning of the above tests, should the chlorine pressure gauge on the chlorinator fail to record any pressure shut off cylinder valve immediately. Crack open the valve of another cylinder and close it again in one continuous motion to check out the possibility that the first valve was inoperative. If no pressure is recorded when the second valve has been opened it is likely the feed pipe is plugged or other operating problems exist. Do not attempt to repair or make adjustments to any part of the chlorine system until the chlorine gas now trapped in the feed pipes from cylinder to chlorinator has been released.

Put on a self-contained air pack with full face piece, loosen one of the feed pipe connections and allow the trapped gas to escape *slowly* from the piping. Wait until the room has been cleared of all escaping gas then make the necessary repairs or adjustments.

The connecting and testing of valves and feed pipes for one ton cylinders to header or chlorinator is to be followed as precisely as described for the 150 lb. cylinders.

CLOSING THE VALVE

When all the chlorine has been discharged from the cylinder, the valve should be closed before the pressure in the cylinder reaches zero. In closing, *use the wrench provided*, grasping the valve in one hand and tapping the wrench in a clockwise direction with the palm of the other. If the valve does not close tightly on the first trial, it should be opened and closed lightly several times until proper seating is obtained. Under no circumstances should a hammer or any other implement be used to effect a tight closure of the cylinder valve. The outlet cap should be immediately replaced upon disconnecting the cylinder so that the valve parts will be protected from the moisture in the atmosphere. As in the case of full cylinders, the protective bonnet should be screwed in place as soon as the cylinder is disconnected.

The outlet cap of each valve is fitted with a gasket which is designed to fit against the valve outlet face. If a valve leaks slightly after closing the leak may be stopped by drawing up the valve cap tightly.

Should the gasket not be in position, an outlet cap may be taken from another cylinder or a suitable gasket may be cut from an asbestos or synthetic rubber sheet. When the valve cap is used to stop a leak, the gland nut should also be well tightened.

FEED PIPE SUPPORT

The feed pipe or flexible coil from the header to the cylinder should be supported while the empty cylinder is being replaced by a full one. For example, support it on another cylinder, use a hook, or a stick from the floor up (a broom would be handy). This will prevent any kinking or weak spots from developing in the pipe.

If the pipe line is to be disconnected for any length of time, there is a danger of moisture forming in the line. Plug the open end of the pipe using a cloth, and shut the auxiliary valve.

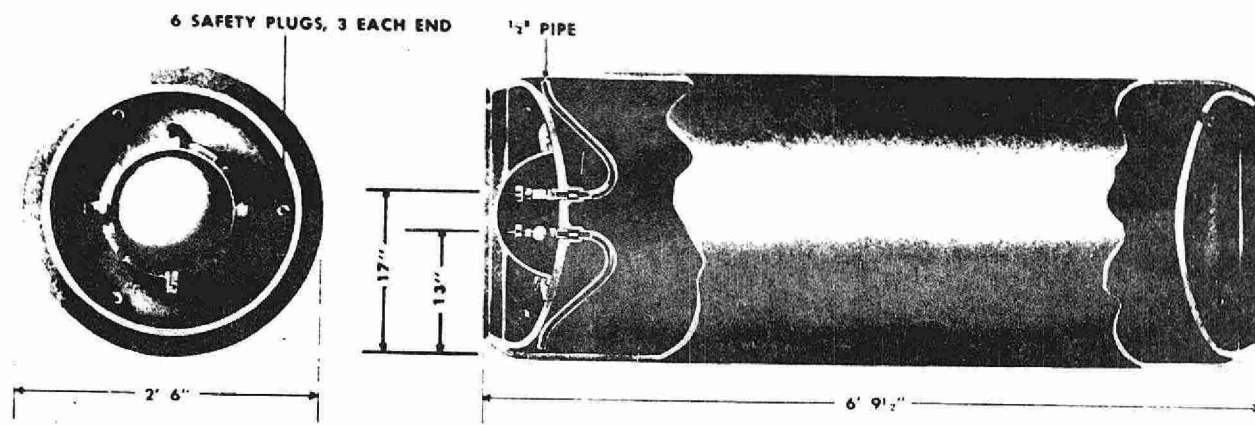


Fig. 5-7 Cross-Section of Ton Container

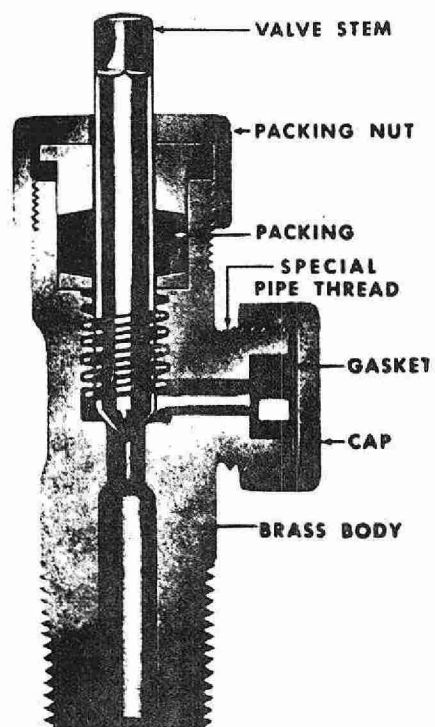


Fig. 5-8 Cross-Section of Ton Container Valve

ONE TON CYLINDERS - STORAGE AND HANDLING

One ton cylinders must be moved by an approved lifting bar and hoist, *and not by rolling them along the floor.*

General storage conditions are the same for both large and small cylinders.

Outside storage areas should be sheltered from the direct rays of the sun, or from excess cold. It is recommended that cylinders be brought in from the storage area to the chlorine room at least 24 hours prior to their being hooked up to the chlorination system. This allows time for the cylinder temperature to come down (or up) to room temperature.

A ton container has two valves, very similar to the one on the 150 lb. container, in fact, the only difference is that these valves do not have a fusible plug. The ton cylinder has three separate fusible plugs in each end. These will also melt at 160°F and discharge the chlorine from within. The delivery rate of chlorine from a ton container will depend on the temperature of the liquid in the container, but an average flow is about 20 pounds per hour of chlorine gas. The one ton cylinder must be positioned on the scales, so that the two discharge valves are above one another. The top valve will produce chlorine gas. The bottom valve will produce chlorine liquid. (Refer to Figure 5-7 and 5-8).

Never operate valves in such a manner as to isolate chlorine gas or liquid in a line. In some installations using one ton cylinders there is a short length of tubing run between cylinder(s) and evaporator(s). There is a valve on the cylinder and one on the evaporator line. The tubing between the two is full of liquid chlorine in normal operation. If for some reason the one inch valve on the evaporator line was closed and then the cylinder valve shut, this would leave the tubing full of liquid chlorine. It requires only a small increase in temperature to cause a considerable increase in gas pressure. With the tubing full of chlorine and closed at both ends, there is no room for gas expansion and a potentially dangerous situation exists. (see Fig. 5-9).

The safe procedure is to close the cylinder valve first and then allow sufficient time for the chlorine in the tubing to be exhausted by the evaporator before closing the evaporator inlet valve. This is the procedure followed when changing cylinders.

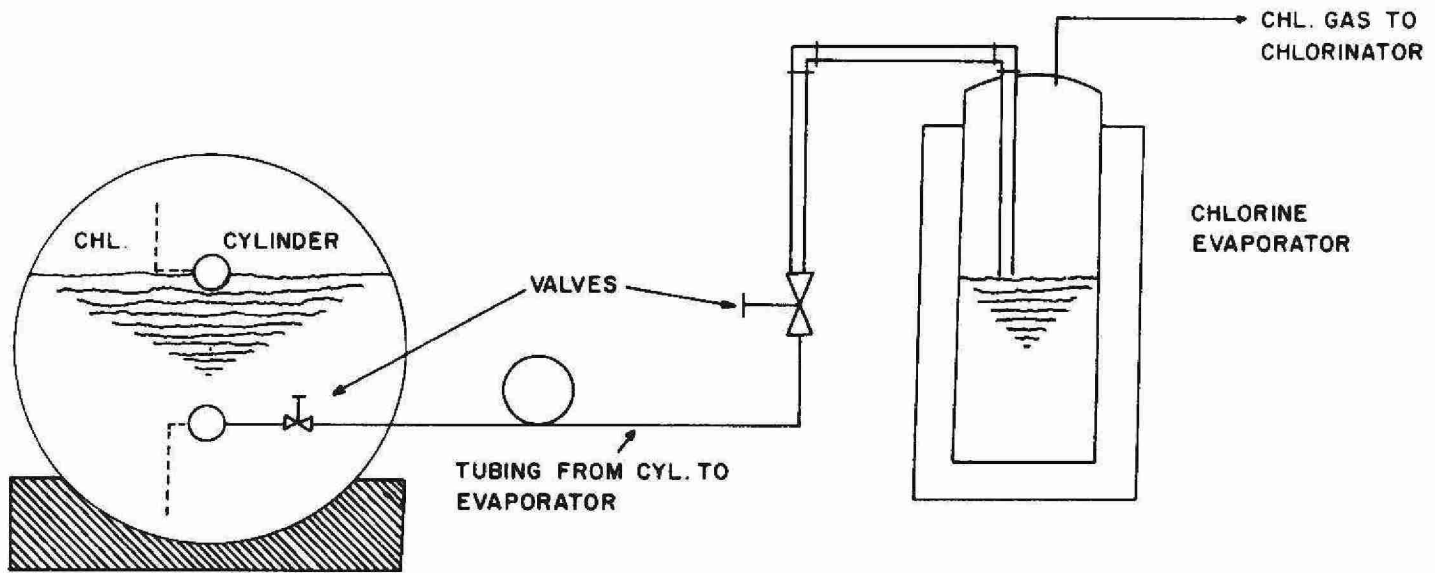


FIG. 5-9

RETURNING EMPTY CYLINDERS TO MANUFACTURER

The final step in returning an empty chlorine cylinder to the manufacturer requires that the portion of the green warning tag below the perforated line be removed. By this means the cylinder is identified as an empty container. If a full or partially full chlorine cylinder is being returned, then the green warning tag should be left intact.

NOTES

SUBJECT:

CHLORINATION SAFETY

TOPIC: 6

OPERATING SAFETY
INSTRUCTIONS

OBJECTIVES:

Trainee will be able to describe and/or demonstrate operating safety instructions regarding the following:

1. Chlorine exhaust fan
2. Self-contained air pack
3. Chlorine leaks
4. Changing cylinders
5. Yoke, adapter and clamp
6. Removing green slime
7. Renewing metal chlorine gas piping

OPERATING SAFETY INSTRUCTIONS

1. The chlorine exhaust fan must be turned on at all times when entering the chlorine room, whether for a routine check or for servicing or repairing leaking equipment while wearing a mask.
2. In all cases where the concentration of the chlorine gas in the air is unknown, a self-contained air pack must be worn.
3. Do not start up or operate a chlorinator or turn on a chlorine cylinder unless adequate protective equipment (air pack respirator) is on hand in the chlorine room area.
4. A self-contained air pack must be worn when it is necessary to locate and stop small leaks in the piping or when making any repairs or adjustments to *leaking* equipment.
5. All persons using the gas protective equipment must be trained in its use and maintenance.

6. A self-contained air breathing unit must not be used unless the air cylinder is fully charged. Air cylinders must be completely recharged after each use.
7. When a leak occurs in a chlorinator room, doors should not be left open leading into any other part of the building. Only doors to the outside should be opened.
8. Water should never be applied to a chlorine leak because of the added corrosive action created by the water and chlorine mixture.
9. Plastic coated gloves should be worn when changing cylinders.
10. Whenever possible, two men should be present when changing chlorine cylinders.
11. Do not lift a cylinder (150 lbs.) up onto the scales. Use a ramp.
12. When connecting the piping from the cylinders to the chlorine machine or whenever it is necessary to break a connection and recouple it, a new lead or fibre washer must be used each time.
13. The yoke, adapter and clamp should be soaked in kerosene, cleansed with a wire brush and the slide and threaded adjustment screw lightly smeared with a light grease.
The yoke adapter should be inspected for rounded or worn edges at the contact point of the adapter clamp.
14. The piping from the cylinders to the header located on the wall or to the chlorine machine must have an inverted loop of not less than 10" in diameter in its length. The loop acts as a flexible coupling.
(see Figure 5-4).

15. A green slime, due to the gas and/or the chemical reaction, may form where a leak was repaired. A dry cloth should be used to wipe away the slime. The dampness of a wet cloth would combine with the slime, possibly creating another leak.

NOTE: If this green slime has dried to a dust, do not blow it with your mouth or brush or wipe it unless the area is completely ventilated.

AVOID BREATHING THIS DUST. Even minute particles are highly dangerous.

16. All metal chlorine gas piping should be renewed leading from the cylinders to the header or chlorinator after each season of use.

If chlorination is continued for the full year the pipes must be replaced at the end of each year of operation.

Flexible metal chlorine gas piping should be replaced immediately if bent or twisted during cylinder change-over.

NOTE: Do not attempt to clean and re-use the pipes. All black iron pipes used as header pipe for gas or liquid chlorine should be replaced after 5 years of service.

17. When using chlorinated powder or chloride of lime for dusting, etc., a proper type of eye shield and gloves must be worn.

NOTES

SUBJECT:

CHLORINATION SAFETY

TOPIC: 7

LEAK DETECTION AND
REMEDIES

OBJECTIVES:

Trainee will be able to describe and/or demonstrate the following:

1. Safety procedures - leak detection
2. General rule to follow when leaks are encountered
3. Types of leaks encountered - and their remedies.

GENERAL

When working with chlorine, care should be taken to follow the prescribed procedure so that mistakes are not made. However, suitable gas masks should be available so that emergency measures can be taken. The chlorinating room itself should be adequately ventilated with a separate ventilating system capable of removing the air from the room once every four minutes. This ventilation should be located at a low level in the room because the chlorine gas is heavier than air. Ideally, there should be two exits from a room containing chlorine containers and the doors should open outwards to facilitate rapid exit. Gas masks should be located just outside the chlorinating room as should the switches for the ventilating system.

SAFETY PROCEDURES - LEAK DETECTION

1. Detect leak by odour.
2. Procure and adjust gas mask for immediate use.

NOTE: Gas masks should be located OUTSIDE of the chlorine room on the wall adjacent to the door leading to the chlorine room.

3. Turn on exhaust fan of chlorine room.
Check fan discharge point and be sure personnel or equipment are not in the way.

4. Shut off cylinders.

If leak is large, or if equipment has been leaking for some time, room is full of gas.

NOTE: *No tests can be made on equipment for leaks until room is cleared.*

DO NOT UNDERTAKE A REPAIR ALONE.

5. Notify supervisor immediately.

6. To test for leak AFTER room is cleared:

(a) use bottle of concentrated ammonia; swab near joints, piping or valves suspected. *White fumes of ammonium chloride indicate a chlorine leak.*

(b) crack open cylinder FARTHEST from chlorinator until gauge shows approximately 40 lbs.

(c) shut off cylinder and test system to find leak(s). It may be necessary to repeat above action several times to find all leakage.

7. When location of leak is found:

(a) mark it off clearly

(b) shut off gas supply and keep supply shut off until leak is repaired.

(c) use proper tools for repair; do NOT handle equipment with unnecessary roughness and thereby risk another accident.

8. If leak is not repaired before shift change:

(a) advise next operator of what has happened

(b) advise him of procedures to follow

NOTE: *If operator of first shift is alone, he should enlist the aid of the operator relieving him to check out equipment, repair leak and leave equipment in operational order before leaving.*

TYPES OF LEAKS ENCOUNTERED - AND THEIR REMEDIES

1. Liquid Leak

One basic and very important recommendation when dealing with chlorine leaks is to always keep the leak in the vapour phase. This is usually quite simple in the case of cylinders since they are stored and used in an upright position. With tonners, however, the leak could easily be liquid chlorine through a valve or a fusible plug. Liquid chlorine will vaporize to approximately 450 times its volume as a gas, hence the leak will be greatly reduced by rolling the tonner (if possible) into a position where gas is coming off. Another big advantage to a gas leak is the fact that as gas is coming off, the liquid is refrigerating itself and lowering vapour pressure, hence the decrease in volume within a reasonable period of time.

2. Leak at Valve Packing

This could have been caused by packing having dried out. In this case, chlorine will be coming out around the valve stem and cannot be stopped by tightening down the packing gland nut. This should only occur when valve is opened.

REMEDY - if leak is very slight, hook up cylinder and start drawing chlorine at as fast a rate as possible. This should quickly reduce the pressure and probably stop the leak. If leak is of major proportions and does not respond to this treatment, shut off valve - set cylinder outdoors in the shade and call supplier who will pick up cylinder or replace the packing.

3. Leak at Fusible Plug

This is usually due to corrosion from moisture, either internally or from the outside.

(a) Cylinders

One manufacturer has a special clamp with a rubber pad and steel backing which easily controls this type of leak.

The adapter clamp can also be used to stop this leak. Take a flat file and file the area around the fusible plug flat, and apply a small patch of rubber gasket material with a follow-up piece of metal and clamp this firmly in place.

NOTE: This emergency device now leaves the cylinder without protection from high temperatures so that every attempt to use this cylinder up as rapidly as possible should be made.

(b) One Ton Container (Tonner)

Leak can be at fusible metal or in thread around plug. If through fusible metal - there is a special clamp, rubber and steel, which readily controls leak. If leak is around threading of fusible plug, the Chlorine Institute emergency kit may have to be used. This equipment is available at strategic points. It should be remembered that when a fusible plug clamp is applied to a 150# cylinder, the safety device no longer exists and great care must be taken to ensure it is emptied as quickly as possible.

Since there are 6 fusible plugs on a tonner, sealing off one of them still leaves 5 operating safety devices which should be adequate under most circumstances.

4. Valve Stiffness

Valves are carefully checked before leaving the manufacturer's plant, but occasionally a valve may be stiff to turn or difficult to shut off tight, i.e., a small amount of chlorine may be getting in by the valve. This may be caused by a small piece of scale or other foreign

matter at the valve seat. Sometimes the valve can be freed by opening and shutting a few times (with the outlet cap in place and by tapping the body of the valve). Actually once the cylinder is hooked up, inability to completely shut off the valve is not important and contents can be withdrawn until empty. When cylinder has been discharged (and only gas remains in it), the outlet cap with a good fibre gasket will effectively stop chlorine from escaping.

5. Valve Defect - "Turning Spindle"

The most troublesome type of valve defect (although fortunately not the most common) is known as a "turning spindle". Actually this is a situation where the brass threading on the valve body has been stripped by the harder monel metal of the valve stem.

If this condition develops *after* the cylinder is hooked up to the chlorination, the simplest and safest way to deal with it is to continue withdrawing chlorine until the cylinder is empty. However, if the cylinder has not yet been hooked up, then an emergency device is required to deal with the situation.

One manufacturer, CIL, has developed a small unit which fits on top of the valve, and by exerting pressure against the packing gland nut pushes the valve stem into position. While this device will work in most instances, there are some situations where the use of the larger Chlorine Institute equipment with the capping devices is required.

6. Removing Valve Outlet Cap (on Cylinder or Tonner)

ONE VERY IMPORTANT WORD OF CAUTION - when taking off the valve outlet cap (on cylinders or tonners) *DO SO VERY SLOWLY*. Actually, if there is a leak of chlorine past the valve, this will be very noticeable after the cap has been slackened only one turn. The ammonia bottle should be

used at this stage, particularly if a mask is being worn by the operator. Actually, very small concentrations of chlorine can be detected by the nose, and for this reason it is sometimes desirable not to wear a mask at this stage - just in case there are leaks. However, the mask should be immediately available if required.

7. AS A LAST RESORT - CONTACT MANUFACTURER!

The situation may be easily corrected by the operator after discussion with the manufacturer by phone - on the other hand, the leak may be more difficult to correct, and the manufacturer's technical personnel will be called upon bringing the appropriate emergency equipment. However, this can usually be determined by phone.

NOTES

NOTES

SUBJECT:

CHLORINATION SAFETY

TOPIC: 8

PROPERTIES AND
PHYSIOLOGICAL EFFECTS
OF CHLORINE

OBJECTIVES:

Trainee will be able to:

1. define the following chlorine properties: colour, density, expansion rate, solubility, flammability and explosiveness;
2. recognize the potential hazards of chlorine, and its physiological effects.

CHLORINE PROPERTIES

Chlorine is a greenish-yellow gas with a penetrating and characteristic odour. It is $2\frac{1}{2}$ times as heavy as air, and one volume of liquid chlorine equals 450 volumes of chlorine gas. It can be compressed into a liquid which has a clear amber colour. At -29°F it has zero vapour pressure. However, as the temperature rises so does the vapour pressure and at 68°F it is 82 psi gauge pressure. This characteristic has to be considered when

- (1) feeding chlorine gas from a cylinder
- (2) dealing with a leaking cylinder.

Chlorine has a high co-efficient of expansion. For example, a temperature rise of 50°F (say 20°F to 70°F) will increase the volume from 84% to 89%. This expansion could easily cause rupture of a cylinder or line which was full of liquid. This is the reason for the regulation that all chlorine containers must not be filled to more than 85% of their volume.

Chlorine by itself is non-flammable and non-explosive, but it will support combustion.

TABLE 8-1

CHLORINE

Greenish Yellow Colour
Heavier than Air
High Rate of Expansion
Moderately Soluble in Water
Non-Flammable and Non-Explosive
Supports Combustion at High
Temperature

PHYSIOLOGICAL EFFECTS

Chlorine can be detected by smell, even in very small dosages. The least detectable amount of chlorine in the atmosphere is about $3\frac{1}{2}$ ppm, and when this occurs, the trainee should be alerted to potential hazards, such as leaks, or faulty equipment. At higher concentrations, chlorine will have physiological effects. The maximum amount that can be inhaled for one hour without serious effects is about four (4) ppm. At fifteen (15) ppm, chlorine will cause irritation of the throat; at thirty (30) ppm, it will cause serious spells; and at forty (40) to sixty (60) ppm, it is extremely dangerous for one half-hour exposure. A few breaths of air containing 1,000 ppm would be lethal.

Because higher concentrations of chlorine cause irritation of eyes, coughing and laboured breathing, it is unlikely that any person would remain unprotected in a contaminated area unless he were unconscious or trapped. The symptoms of advanced stages of exposure are retching and vomiting followed by difficult breathing. In extreme cases, the difficulty of breathing may increase to a point where death can occur from suffocation.

TABLE 8-2

Physiological Response to Various
Concentrations of Chlorine Gas

<u>RESPONSE</u>	<u>CHLORINE</u> <u>P.P.M.</u>
Least amount required to produce slight symptoms (of poisoning) after several hours exposure.....	1.0
Least detectable odour.....	3.5
Maximum amount that can be breathed for one hour without serious effects.....	4.0
Least amount required to cause irrita- tion of throat.....	15.1
Least amount required to cause coughing.	30.2
Amount dangerous in 30 to 60 minutes....	40-60
Amount likely to prove fatal after a few deep breaths.....	1000

NOTES

SUBJECT:

TOPIC: 9

CHLORINATION SAFETY

FIRST AID SUGGESTIONS

OBJECTIVES:

Trainee will be able to demonstrate and/or describe the following suggested first aid procedures regarding chlorine:

1. Removing patient from gas area
2. Placing patient on back, elevate head and back
3. Calling physician immediately
4. Removing clothing contaminated with liquid chlorine
5. Administering mixture of carbon dioxide and oxygen
6. Giving milk in mild cases as a relief from throat irritation
7. Administering artificial respiration
8. Cleansing the eyes
9. Cleansing the skin splashed with liquid chlorine.

NOTE: *The adoption of first aid procedures for any particular case should be endorsed by a qualified physician.*

FIRST AID SUGGESTIONS

These suggestions are based on the recommendations of the Chlorine Institute but their adoption for any particular case should be endorsed by a qualified physician.

1. Remove patient from gas area. Patient should preferably be kept in a warm room (about 70°F). Supply blankets if necessary. Keep patient warm and quiet. Rest is an essential part of the treatment.

2. Place patient on back, elevate head and back.
3. Call a physician immediately.
4. Remove clothing contaminated with liquid chlorine, or chlorinated water promptly. Keep patient warm with blankets.
5. Carbon dioxide and oxygen mixture, with carbon dioxide not exceeding 7%, may be given. This mixture, ready prepared and sold with the necessary apparatus, can be administered intermittently for periods of two minutes followed by two-minute rest periods over a total period not to exceed thirty minutes. Instructions of the supplier of the gas apparatus should be carefully followed. If carbon dioxide and oxygen mixture is not readily available, then oxygen alone may be used.
6. Milk may be given in mild cases as a relief from throat irritation.
7. If breathing has apparently ceased, immediately start the artificial prone pressure method of resuscitation (Schafer). Do not exceed 18 movements per minute. If possible, assist respiration with an inhalator.
8. When eyes are irritated with chlorine, wash repeatedly with water and then with 1% boracic acid solution. Castor or olive oil drops may be used. In severe cases of eye contamination due to chlorine, use bubbler fountain, hose, or eye cup. Irrigate for 15 minutes, rest for 10 minutes and irrigate for 5 minutes. A routine of 5 minutes irrigation and 10 minutes rest should then be followed for one hour. Prompt action is absolutely essential to protect eyesight.

9. Areas of the skin which have been splashed with liquid chlorine or chlorinated water should be repeatedly washed with water. After thorough washing, any burned area should be treated with clean vaseline and bandaged loosely.

If facilities are available, it is generally recommended that patients be removed to hospital as soon as possible, unless recovery from chlorine exposure is prompt and the exposure mild.

NOTES

SUBJECT:

TOPIC: 10

CHLORINATION SAFETY

EMERGENCY PLAN

OBJECTIVES:

Trainee will be able to

1. describe and/or demonstrate the emergency procedures to follow if there is a leak from a cylinder which cannot be stopped or repaired.
2. Contact the following person or persons:
 - a. his immediate supervisor
 - b. the Fire Department
 - c. the Police Department
 - d. the chlorine supplier
 - e. the Medical Officer of Health
 - f. the Ontario Water Resources Commission District Engineer, or Supervisor of Water Works.

NOTE: *The trainee is not expected to perform the second objective while on the course, but rather be aware of the person or persons to be contacted when an emergency arises while he is on the job.*

GENERAL

Chlorine is a potential killer, if the chlorine handling equipment, although well designed, becomes defective or if people become careless. Even when all regulations are observed, safety practices followed and well-trained crews are employed, there is still a small chance that an accident will occur.

EMERGENCY PLAN

Assume there is a leak from a cylinder which cannot be stopped or repaired, such as a leaking fusible plug, damaged cylinder valve, or a hole in the cylinder body. It is recommended that the following steps be taken:

1. The operator must protect himself AT ALL TIMES during the emergency, and be sure he will not be overcome by the leaking gas. An air pack should be used when he is in the vicinity of the leaking cylinder.
2. The operator should contact his supervisor immediately and advise him of the problem.
3. If he cannot contact his supervisor, the operator should telephone the Police Department to tell them of the problem. He should advise the police of the wind direction (if any) so they in turn can alert the residents who may be in the path of the gas and have the area evacuated.
The police or operator should also contact the Fire Department who, in turn, should have someone with an auxiliary air pack go to the plant or leaking area. This person (or persons) could then stand by while the operator further attempts to stop the leak.
4. One basic and very important recommendation when dealing with chlorine leaks is to always keep the leak in the vapour phase. Cylinders and tonners should be placed into a position where gas and not liquid is coming off. Chlorine may be absorbed in a solution of caustic soda, soda ash or hydrated lime. Table 10-1 indicates the solutions required to absorb either a cylinder or ton container of liquid chlorine.

TABLE 10-1

ALKALINE SOLUTIONS FOR CHLORINE ABSORPTION						
Chlorine Container Size	CAUSTIC SODA		SODA		HYDRATED LIME	
	Pounds	100% Water Imp.Gals.	Pounds	100% Water Imp.Gals.	Pounds	100% Water Imp.Gals.
150 pound	188	60	450	150	188	188
One Ton	2500	800	6000	2000	2500	2500

5. The supplier, or manufacturer, of chlorine should be contacted. One company, C-I-L, operates an "Emergency Telephone Call Service" designed to provide assistance at any hour of the day or night.
6. Inter-connecting doors within the plant should be *CLOSED, AND THE CHLORINE ROOM SEALED OFF*. The chlorine room exhaust fan should *NOT* be turned on as this would release an excessively strong concentration of chlorine outside the plant. The chlorine will slowly escape by itself if left alone, which is a better alternative, particularly if the leak occurs at night.
If the leak occurs in the daytime, the sun will dissipate it quite effectively, even on a cloudy day. If the weather is hot and humid, or rainy, or foggy, the chlorine will not dissipate as quickly, and there is very little which can be done except to evacuate all the people in the area. If there is a wind, the residents who may be in the path of the gas must be evacuated.
7. If the leak occurs in a water treatment plant, it may be necessary to shut down and use only the water in the reservoir(s). If this is inadequate and the plant cannot be shut down, then the Medical Officer of Health (MOH) should be advised so that he in turn can warn the residents to boil the water from the tap before use.
8. The Ontario Water Resources Commission (OWRC) District Engineer for the area should be advised immediately as well.

If he cannot be reached, a call to the Supervisor of Water Works, Division of Sanitary Engineering, at Head Office, should be placed. The telephone number is (416) 365-1491.

9. All events which occurred during the emergency should be recorded in the Operator's Daily Log Book.
10. If the leak occurs in a wastewater treatment plant, the plant can still continue to operate. Again, all events which occurred during the emergency should be recorded in the Operator's Daily Log Book.

NOTE:

WATER WORKS OPERATORS

IN CASE OF

CHLORINATION SYSTEM BREAKDOWN DO
NOT PUMP UNCHLORINATED WATER TO THE
DISTRIBUTION SYSTEM. NOTIFY THE
SUPERINTENDENT IMMEDIATELY. IF CHLOR-
INATION SYSTEM CANNOT BE RESTORED TO
WORKING ORDER IN REASONABLE TIME NOTIFY
THE MEDICAL OFFICER OF HEALTH AND THE
DISTRICT ENGINEER (OWRC), OR SUPERVISOR,
WATER WORKS, SANITARY ENGINEERING DIVISION,
TELEPHONE NUMBER (416) 365-1491.

NOTES

NOTES

SUBJECT:

TOPIC: 11

CHLORINATION EQUIPMENT

COMPONENTS

OBJECTIVES:

Trainee will be able to identify (orally or in writing) the principal components of the chlorination system.

The principal components are:

1. chlorine gas cylinder
2. chlorine weighing scales
3. flexible coils
4. chlorine manifold or header
5. chlorinator (including chlorinator valves)
6. water pressure regulator
7. booster pump
8. strainer preceding injector
9. valves (excluding chlorinator valves) cylinder, auxiliary, header, check, relief, pressure reducing
10. evaporator
11. exhaust fan
12. safety devices (alarm system, rupture discs)
13. recording charts and pens
14. compressors

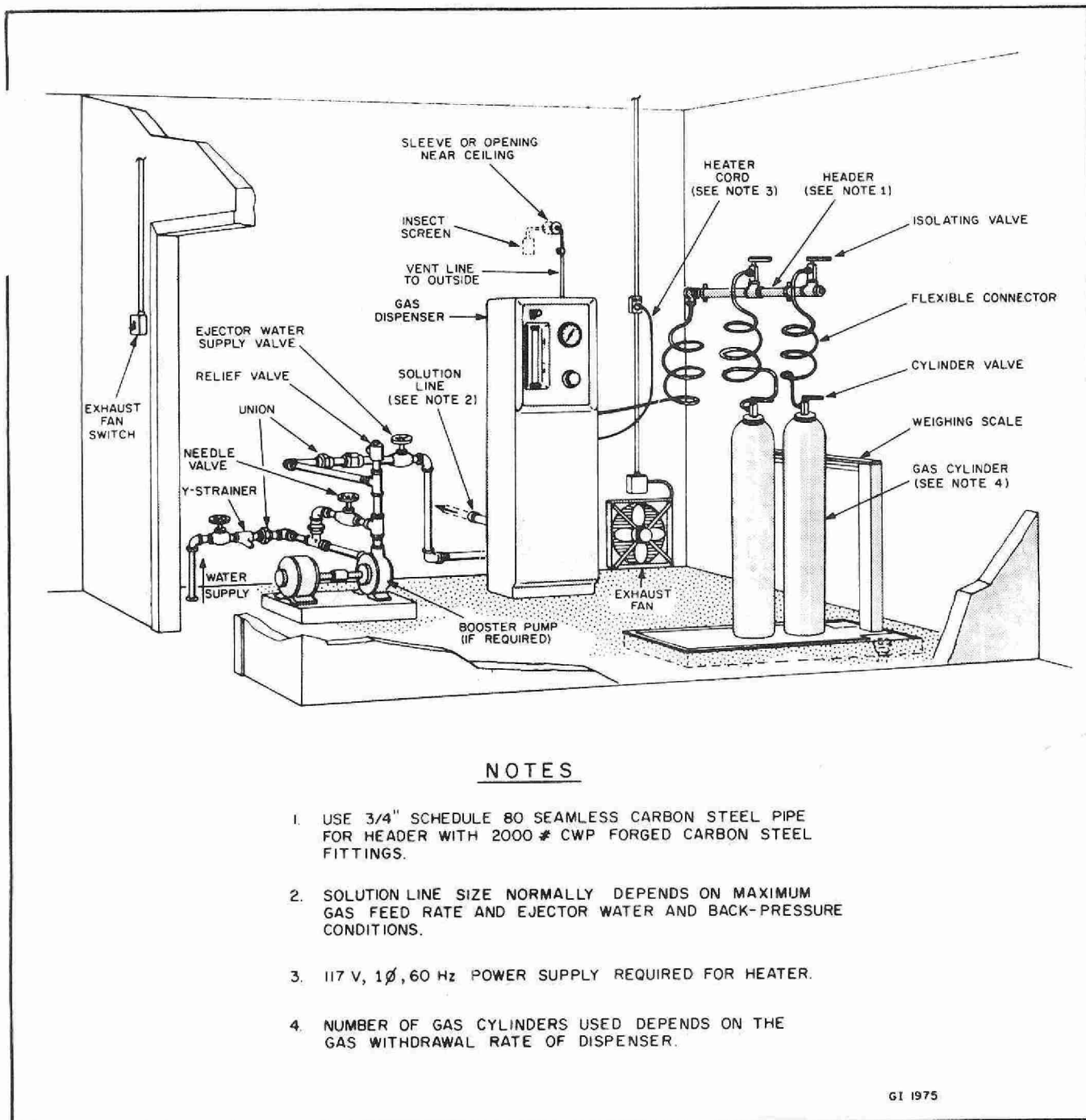


Fig. 11-1 TYPICAL GAS DISPENSER INSTALLATION

COMPONENTS

1. Chlorine Gas Cylinder(s) (see Fig. 11-1)

Chlorine gas is shipped from the supplier to the water or wastewater treatment plant in 150 lb. cylinders, one ton cylinders and in tank cars. Chlorine demand will govern the amount shipped and the type of container used. (See Chlorination Safety, Topic 5, for further details on handling and storage).

2. Chlorine Weighing Scales (see Fig. 11-1)

The only reliable method of determining the contents of a cylinder is by weighing.

The types of scales used in the water and wastewater treatment industry are (a) beam scales, (b) dial scales and (c) special types of scales:

- (a) Beam Scales are the most common type used in smaller water and sewage treatment plants. Beam scales have a knife-edge type of platform. The weight to be measured is placed on the platform and determined by moving a counterweight along the beam.
- (b) Dial Scales usually have the same type of knife-edge platform as beam scales, but the weight to be measured is indicated directly on the dial. The tare weight of the cylinder can be compensated for as the amount of chlorine in the cylinder can be read directly on the dial.
Dial scales are used extensively to measure the amount of chlorine in ton cylinders.
- (c) Special types of scales are also used: electronic, loss of weight recorders, transmitters for remote reading and/or recording, 150 lb. container scales and other sundry types. Application of these types of scales would depend on the particular circumstances in each case.

3. Flexible Coils (or pigtails) (see Fig. 11-1)

Flexible coils are used to connect the cylinder valve (or the cylinder) to the manifold or header valve. They allow movement of the cylinder on the weigh scales, and allow easy connecting and disconnecting of the cylinder.

NOTE: 1. Do NOT make any sharp bends or kinks that could cause blockage in the line when using flexible coils.

2. When connecting or disconnecting the coil and the cylinder, always use the 2 wrenches designed for that purpose.

4. Chlorine Manifold or Header (see Fig. 11-1)

The chlorine manifold or header is that section of SOLID piping between the chlorinator and cylinder or cylinders through which the chlorine gas must pass. The flexible coils from individual cylinders are connected to it. Valves should be installed at each flexible connection to permit isolation of a cylinder from the system.

5. Chlorinator (including chlorinator valves) (see Fig. 11-1)

The chlorinator consists of the following:

(a) Chlorine Pressure Regulating Valve (CPRV)

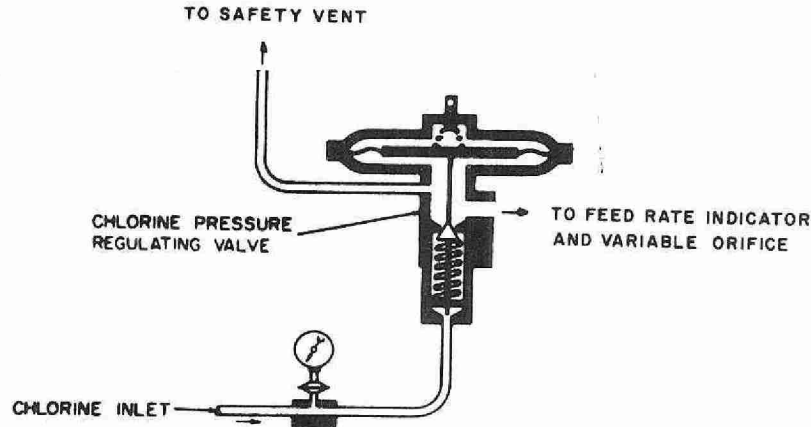


FIG II-2 CHLORINE PRESSURE REGULATING VALVE (CPRV)

Upon leaving the header, the gas chlorine enters the chlorinator via the CPRV. The CPRV is a diaphragm valve which works against a spring force. Its function is to maintain the proper operating vacuum ahead of the variable-orifice. The vacuum in the chlorinator must be greater than the spring force in the CPRV to draw chlorine gas into the

chlorinator. The vacuum pulls the diaphragm and stem down; chlorine gas flows through the feed rate indicator at a known pressure. The spring force in the CPRV controls absolute pressure (or vacuum) in the regulating valve (see Fig. 11-2 and Fig. 11-10).

(b) Feed Rate Indicator (or Rotameter)

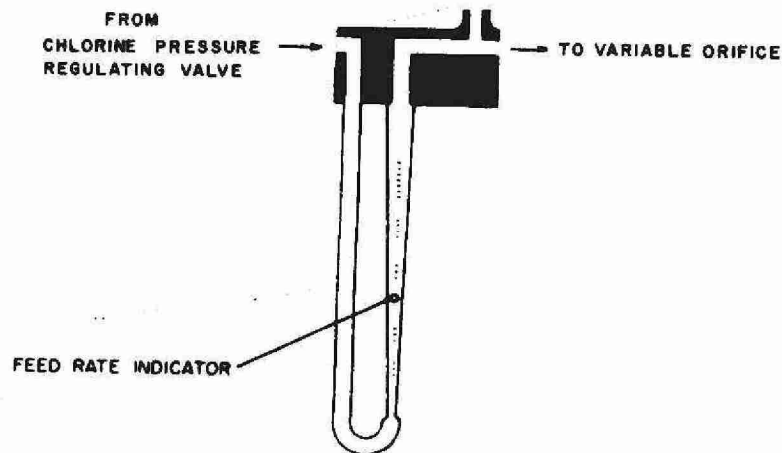


FIG 11-3 FEED RATE INDICATOR

The feed rate indicator, or rotameter (see Fig. 11-3 and Fig. 11-11), is a tapered glass tube with a round ball inside. The ball will position itself in the rotameter according to the chlorine gas flow. The size of the glass tube is determined by the gas flow.

When operating normally, the ball is free to rotate inside the tube. If it is not rotating, the ball is stuck against the inner walls of the tube.

NOTE: Gas flow readings are taken across the centre of the ball, not across the top, or the bottom. Other types of floats are also used, and will depend on the size of chlorinator and the gas flow through the unit.

The feed rate indicator tube and float are pre-determined for a specific maximum capacity and cannot be interchanged. For example, a float from a 10 lb./day maximum capacity rotameter cannot be used in a 20 lb./day maximum capacity tube.

(c) Pressure-Vacuum Relief Valve

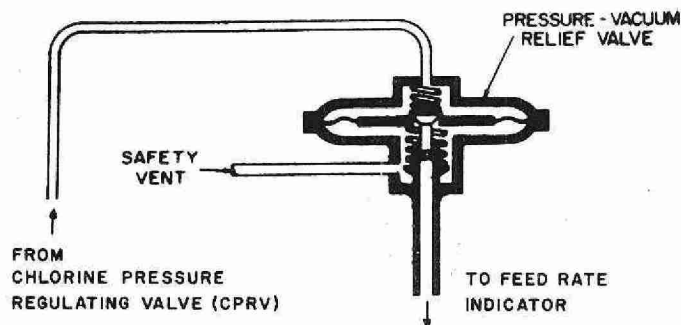


FIG II-4 PRESSURE VACUUM RELIEF VALVE

The pressure-vacuum relief valve is diaphragm operated and is used to provide vacuum relief in the chlorinator system. It prevents a buildup of vacuum which could damage the unit, and vents chlorine to the atmosphere if there are problems in the chlorine pressure regulating valve (see Fig. 11-4 and Fig. 11-12).

(d) Variable Orifice

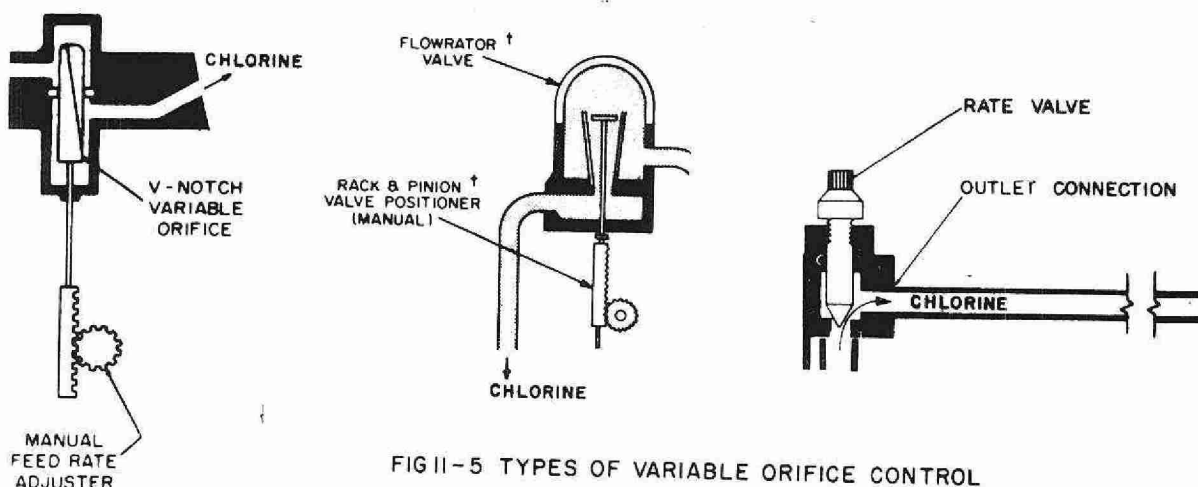


FIG II-5 TYPES OF VARIABLE ORIFICE CONTROL

- (A) V-NOTCH VARIABLE ORIFICE
- (B) FLOWRATOR VALVE
- (C) RATE OR NEEDLE VALVE

The variable orifice is that part of the chlorinator which controls the flow of chlorine through the chlorinator. The orifice can be adjusted manually or automatically and its setting will be dictated by the chlorine demand in the water or wastewater process.

The volume of chlorine passing through the orifice is proportional to its size and to the vacuum differential across the orifice.

There are different types of orifices available, as indicated in Fig. 11-5 (a), (b) and (c):

Fig. 11-5(a) is the V-Notch, used in Wallace & Tiernan chlorinators.

Fig. 11-5(b) is the flowrator valve, used in Fischer and Porter gas dispensers (or chlorinators).

Fig. 11-5(c) is the rate, or needle and seat type orifice found in Advance chlorinators.

(e) Vacuum Regulating Valve

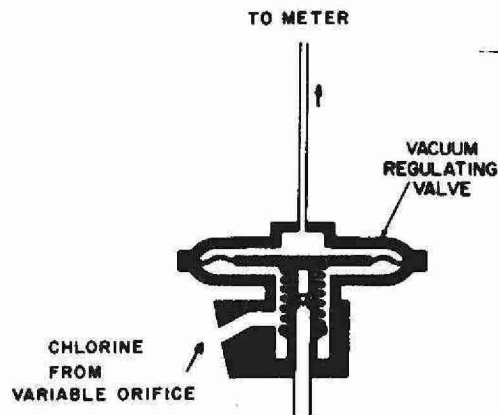


FIG 11-6 VACUUM REGULATING VALVE

The diaphragm, spring-loaded vacuum regulating valve (Fig. 11-6) maintains the proper operating vacuum downstream of the variable orifice. Chlorine passes through the vacuum regulating valve to the injector.

NOTE: In W&T chlorinators, the diaphragms are interchangeable.

In the Fischer and Porter unit, the chlorine pressure regulating valve, the pressure-vacuum relief valve and the vacuum regulating valve form what is called a "stacked diaphragm" (see Fig. 11-7 and Fig. 11-13).

LEGEND

- * - OPTIONAL EQUIPMENT, FURNISHED IF SPECIFIED.
- ** - FIXED RANGE SAFETY STACK REGULATOR FURNISHED WHEN MANUAL RATE VALVE IS SPECIFIED.
- † - COMPONENTS ASSOCIATED WITH THE ADJUSTABLE RANGE SAFETY STACK REGULATOR ONLY, FURNISHED WHEN FLOWRATOR VALVE IS SPECIFIED.

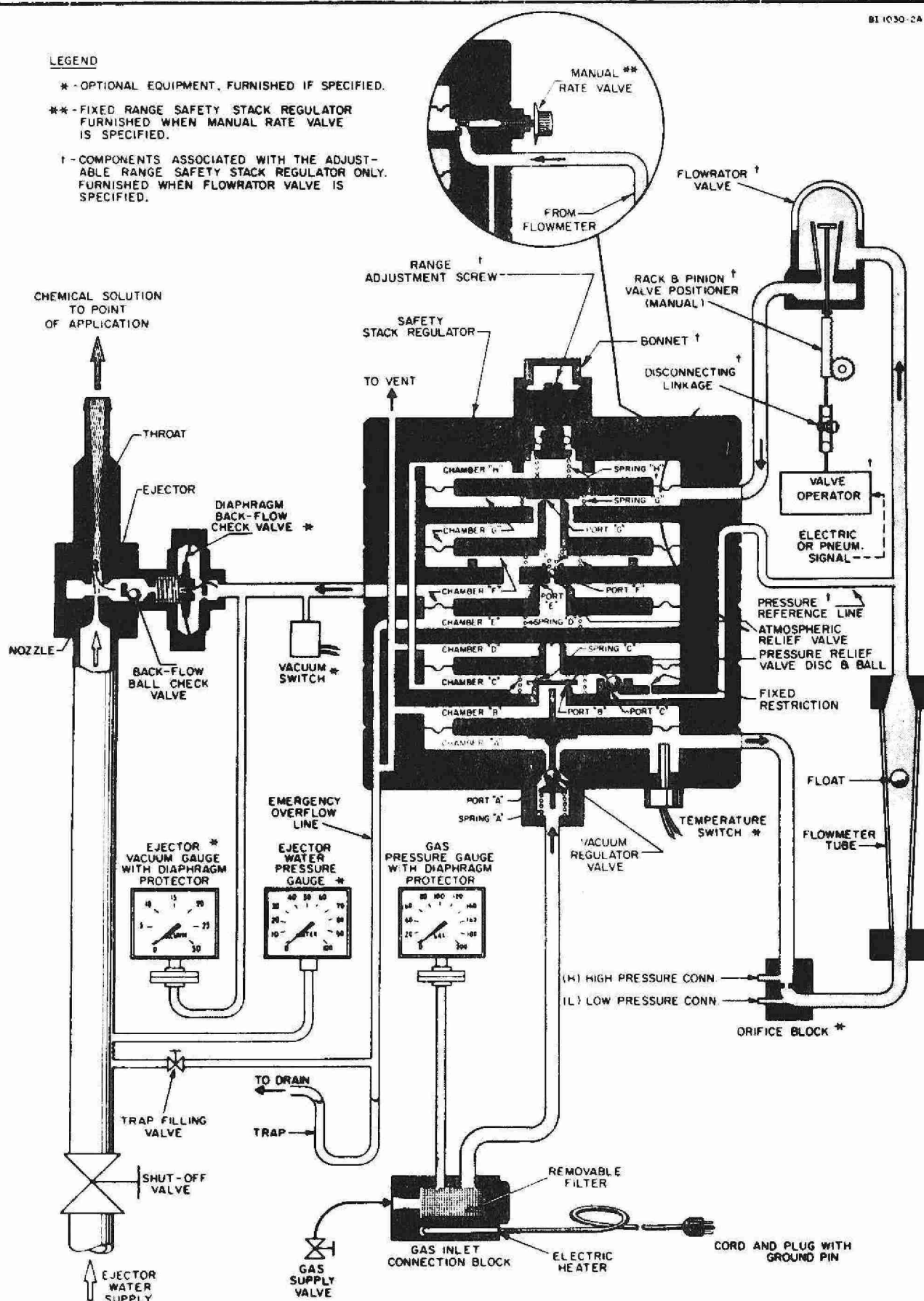


FIGURE 11-7 FUNCTIONAL SCHEMATIC OF THE SERIES 70_3400 GAS DISPENSER WITH FIXED OR ADJUSTABLE RANGE SAFETY STACK REGULATOR

(f) Injector (or Ejector)

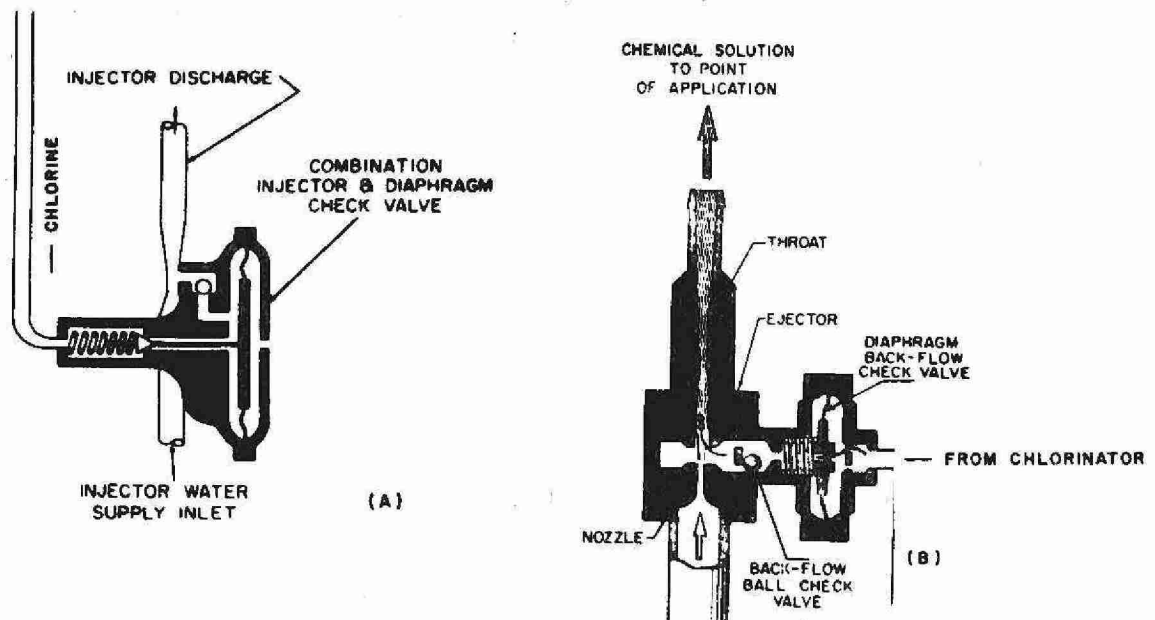


FIG 11-8 (A) INJECTOR (B) EJECTOR

The water-operated injector or ejector consists of a venturi-type nozzle and a diaphragm back-flow check valve. Water enters the venturi under high pressure, low velocity. At the "neck" or nozzle this changes to low pressure, high velocity, thereby creating a partial vacuum. This vacuum draws chlorine gas into the venturi, and the solution of chlorine and water is then discharged to the point of application.

The injector is the first point in the process where the chlorine gas first comes into contact with the water. Total mixture of the solution usually occurs at or below the injector discharge.

Should an accident occur while the operation is under proper vacuum, then air would be drawn into the chlorinator, thus preventing chlorine from reaching the atmosphere. Negative or low pressure permits the use of lighter, corrosion-resistant plastic components.

The back-flow check valve is used primarily to prevent any solution backing up into the chlorine line, leading to possible corrosion of materials (see Fig. 11-8 (a) and (b) and Fig. 11-4 and Fig. 11-5).

NOTE: *The injector is susceptible to wear with time, or if the raw water contains grit particles. It is therefore essential that a strainer precede the injector.*

The injector does NOT have to be installed on the chlorinator.

6. Water Pressure Regulator

Used to control and maintain the water pressure at a constant value and eliminates fluctuations caused by the increase or decrease of the pressure. The installation and use of a water pressure regulator can prevent excessive wear on the injector throat and tailway, cut down on the noise caused by water flowing at very high pressures and permit a steadier operation.

The required water pressure and flow will vary with the amount of chlorine added.

7. Booster Pump (see Fig. 11-1)

Some chlorine installations may not have sufficient pressure at the point of application. In such instances a booster pump is installed to provide the necessary pressure to overcome friction losses and meet the pressure demands of the system.

8. Strainer Preceding the Injector (see Fig. 11-1)

It is recommended that a strainer be installed on the water line and precede the injector. This would prevent any possible grit or foreign material from entering and blocking the injector, or causing undue wear on the injector throat and tailway.

If a booster pump is used in the system, the strainer should precede the pump (the injector comes after the pump).

A "Y" type strainer is used for ease of cleaning.

9. Valves (excluding chlorinator valves) (see Fig. 11-1)

(a) Cylinder Valve (see Fig. 5-2)

Used to open or close individual cylinders.

(b) Auxiliary Valve (see Fig. 11-16 and Fig. 5-4)

At end of flexible coil connecting to the cylinder. If the coil is left disconnected from the cylinder for any length of time, the auxiliary valve is closed to prevent any moisture accumulation in the coil leading to possible corrosion.

(c) Header or Manifold Valve (see Fig. 11-1)

The header valve connects the flexible coil to the fixed piping, or cylinder header. It is used to isolate individual cylinders from the chlorination system.

(d) Check Valve (see Fig. 11-1)

Used to prevent any solution from returning or flowing back into the water line or into the chlorinator.

(e) Relief Valve (see Fig. 11-1)

Used to prevent any excessive buildup of pressure in the water line between the booster pump and the chlorinator.

(f) Pressure Reducing Valve (PRU) in Header (see Fig. 11-17)

Used primarily to control the chlorine gas pressure into the chlorinator. The PRU also helps prevent chlorine gas changing to liquid chlorine in the line between the cylinders and the chlorinator, and should be located as close to the cylinders as possible.

10. Evaporator

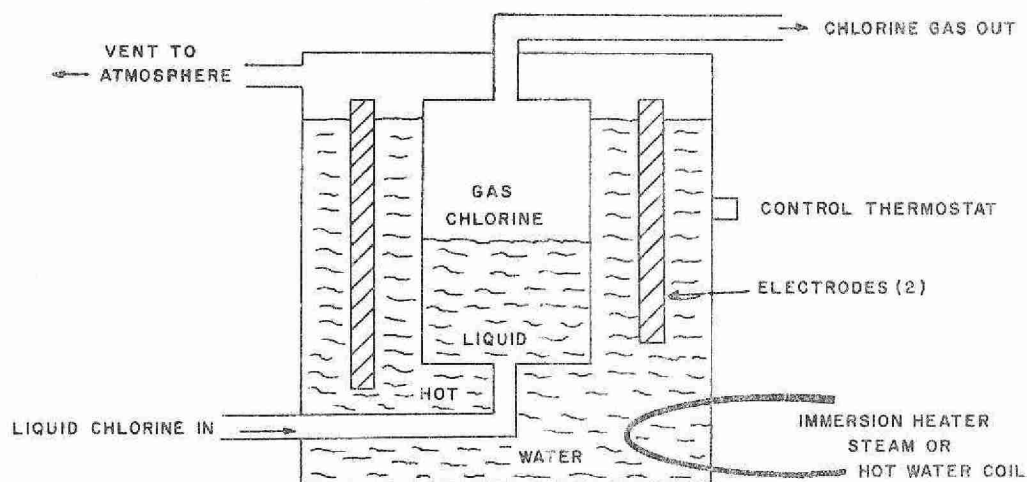


FIG II-9 EVAPORATOR

An evaporator changes liquid chlorine into chlorine gas at a faster rate than is obtained from a container at ambient (room) temperature.

An evaporator is used with one ton containers or tank cars, and not with 150 lb. cylinders. It is also used where large amounts of chlorine gas are required (over 400 lbs./day).

As indicated in Fig. 11-9, liquid chlorine is fed into a chlorine cylinder which is immersed in a bath of hot water. The water is heated by an immersion heater (steam, hot water or electric), and the temperature of the bath is controlled by a thermostat at approximately 160 deg.F. The evaporation rate of liquid chlorine increases with temperature; more liquid chlorine becomes chlorine gas thereby increasing the amount of gas available.

11. Exhaust Fan (see Fig. 11-1)

An exhaust fan is installed in the chlorination room to prevent any accumulation of chlorine gas and to provide a specific number of air changes according to the Department of Labour Code. It is usually mounted

near the floor level on the outside wall of the building. In some cases, the fan is mounted high on the wall or on the roof with an inlet duct going down to within 18 inches of the floor level. The duct inlet must be near floor level to exhaust chlorine gas since chlorine is heavier than air and any accumulation would settle at the floor level.

The louvers and blades on the fan should be inspected regularly to assure trouble-free operation.

12. Safety Devices (see Fig. 11-18)

Safety devices include the following items:

- (a) alarm systems
- (b) rupture discs
- (c) air packs
- (d) first aid kit
- (e) fire fighting equipment

(a) Alarm Systems

In chlorination, alarm systems are used primarily to warn the operator that chlorine is being lost to the atmosphere or of an equipment failure or malfunction. Alarm systems can also be used to send local or remote signals, or to activate other equipment (for example, standby equipment, exhaust fans).

The most common systems in use to detect chlorine in the atmosphere are (i) sensitized paper and (ii) a sensing cell system.

(i) Sensitized Paper (see Fig. 11-18)

Sensitized paper is darkened in the presence of chlorine. Its method of operation is as follows: A photo-electric cell picks up the reflected light from the sensitized paper. This is converted to an electrical current which opens a relay circuit to the alarm.

When the sensitized paper is darkened in the presence of chlorine, the current to the relay

drops. This closes the relay circuit and activates the alarm system.

A sample of air is constantly pumped across the sensitized paper. The paper should be replaced daily, or whenever an alarm condition exists. Normal shelf life of the paper is approximately six months.

(ii) Sensing Cell System

A sample of air is drawn through a sensing cell. Any chlorine present in the air sample will increase the electric signal to an alarm circuit. When the electric signal reaches a pre-set point, the alarm system is activated and remains activated until the chlorine leak is repaired and chlorine is no longer present in the air sample. The electric signal generated by the sensing cell is reduced and the alarm circuit is de-activated.

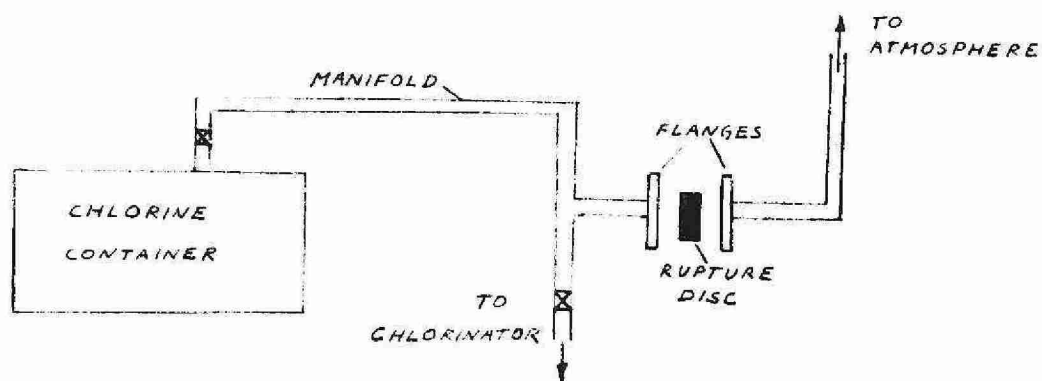
When equipment failure or malfunction occurs, the alarm system is activated by the vacuum within the chlorinator. If the vacuum *increases* beyond the normal operating level, a diaphragm-operated switch activates the alarm system. Vacuum increase is caused by failure of the chlorine supply.

If the vacuum should *decrease* or drop below the normal operating level, the diaphragm-operated switch will activate the alarm system. Vacuum decrease can be caused by failure of the water supply, plugging of injector, increase in pressure downstream of the injector, or any leak in the vacuum system.

(See Topic 13 for the Normal Operation of the Chlorination System).

(b) Rupture Discs

A rupture disc usually consists of a metal diaphragm used on the larger installations, such as ton containers or tank cars. The disc is designed to protect the equipment and will rupture (or break) when the gas pressure in the chlorine manifold system reaches a pre-determined value greater than normal operating pressure, but less than maximum allowable pressure. A typical installation is as follows:



The rupture disc is placed between two flanges in the vent line to atmosphere. The vent line "tees off" the manifold between the chlorine container and the evaporator or chlorinator.

(c) Air Packs

An air pack is a breathing apparatus located *OUTSIDE* the chlorine room and used by the operator when entering the room if a chlorine leak is suspected or present.

(d) First Aid Kit

A first aid kit is a must for every plant. It should be kept complete by replacing items as they are used.

(e) Fire Fighting Equipment

Be sure extinguishers will function when required at all times, and that the Fire Department telephone number can be located quickly in an emergency.

13. Recording Charts and Pens (see Figs. 11-19 and 11-20)

A recording chart is used to record the daily consumption of chlorine. When positioned, the chart must be free to move, and not binding in any way. When changing charts, always check the time to make sure the chlorine consumption is recorded at the proper hour on the chart.

Chart pens are supplied with ink by one of two methods:
(a) capillary tube or (b) trough type.

- (a) The capillary tube type has a double effect: it cleans the tube while loading the pen.
- (b) The trough type pen should be cleaned of all congealed ink at regular intervals and should be replaced when the tips of the pen become worn.

14. Compressors

Compressors used for air control signals must be maintained to produce a clean, moisture-controlled air supply to the instrument. For trouble-free operation, the air should pass through a filtering cell to remove suspended oil and dust particles, and a drying unit to remove moisture.

Used in 400 Lb. Capacity V-Notch Chlorinator

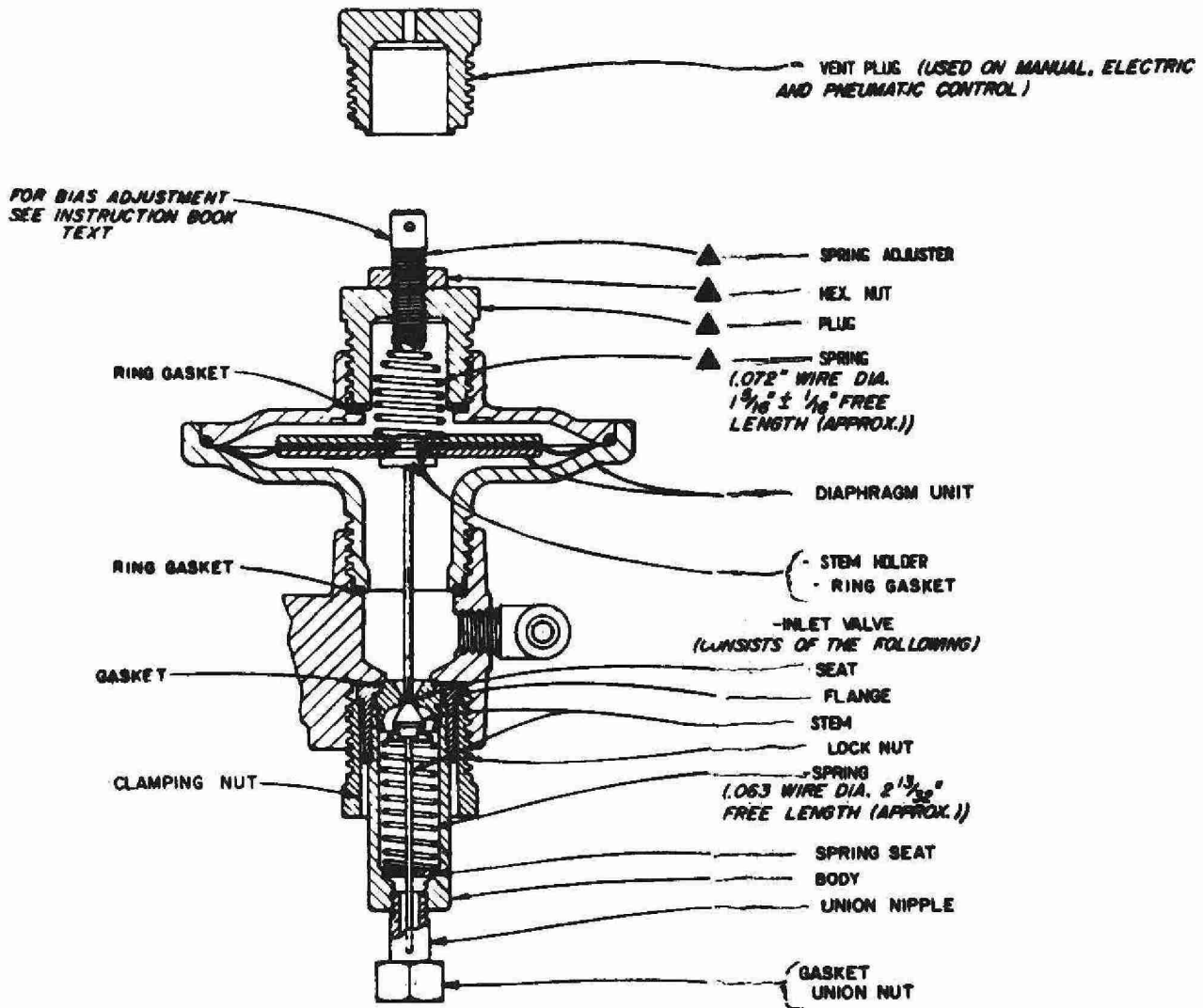
MANUAL, PNEUMATIC & ELECTRIC CONTROL
VARIABLE VACUUM CONTROL▲ USED ONLY FOR VARIABLE
VACUUM CONTROL.

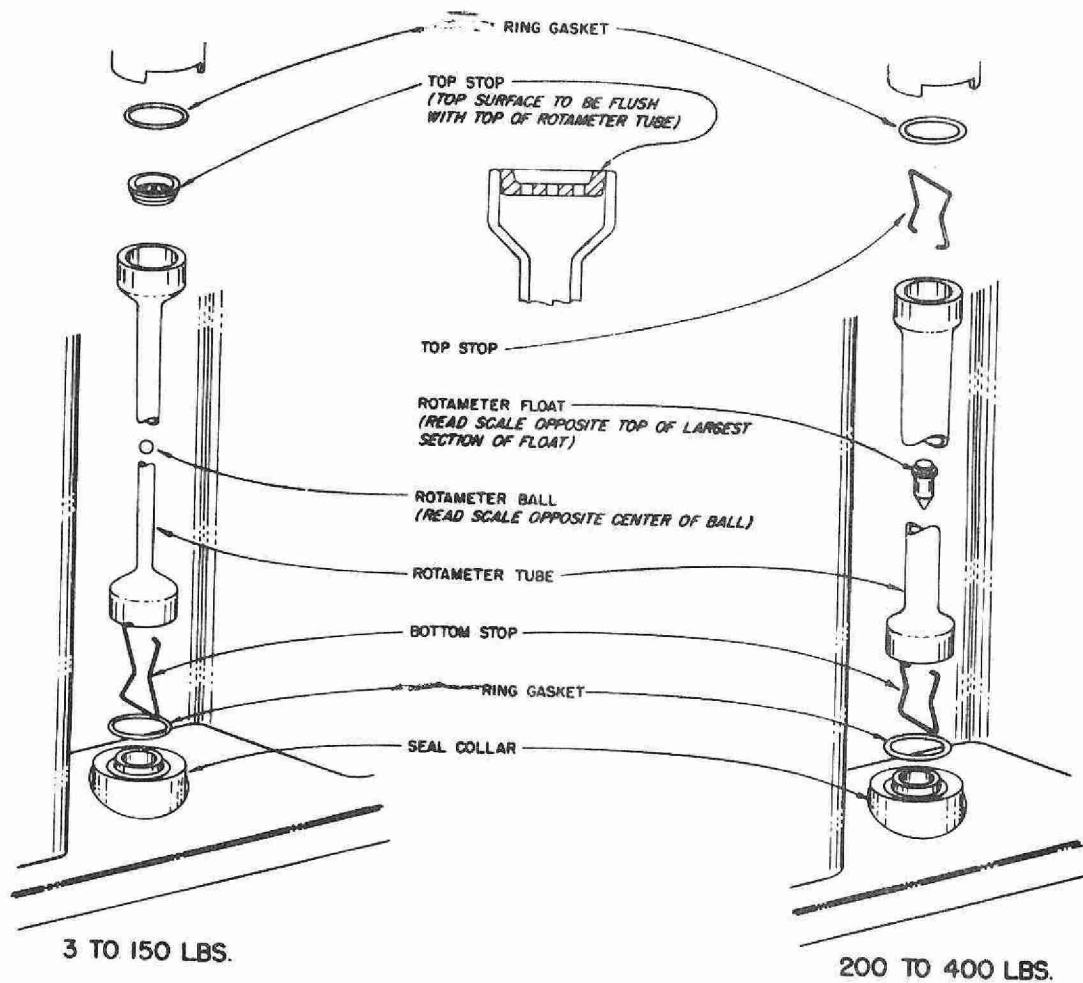
FIG. 11-10

GAS PRESSURE REGULATING VALVE

400 LB. V-NOTCH CHLORINATOR

Chlorine Rotameter Components

PARTS



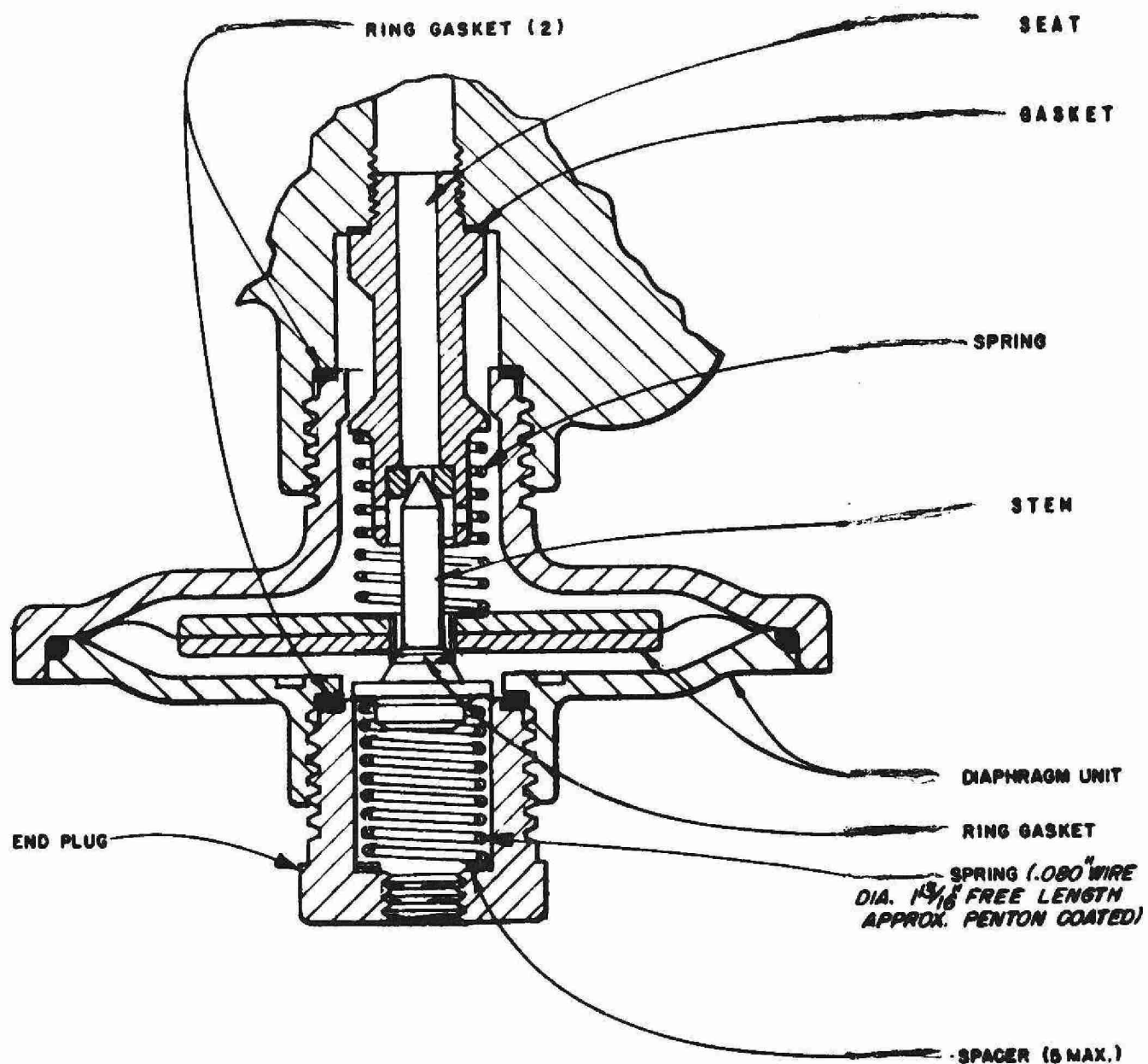
MAXIMUM CAPACITY LBS. PER 24 HRS.	ROTAMETER					
	COMPLETE UNIT	TUBE	FLOAT		STOPS	
			PART NUMBER	DESCRIPTION	TOP	BOTTOM
3	U 20947	P 44058	P 37702	1/8" DIA. RED BALL	P 41212	P 38131
10	UXA 20947	P 44059	P 37702		P 41212	P 38131
20	UXB 20947	P 44060	P 37703	9/32" DIA. RED BALL	P 41212	P 38131
30	UXC 20947	P 44061	NP 150	1/4" DIA. BLACK BALL	P 41212	P 38131
50	UXD 20947	P 44062	P 37705	1/4" DIA. RED BALL	P 41212	P 38131
75	UXE 20947	P 44063	P 37706	5/16" DIA. RED BALL	P 41212	P 38131
100	UXF 20947	P 44064	P 37706		P 41212	P 38131
150	UXG 20947	P 44065	P 37707	3/8" DIA. RED BALL	P 41212	P 38131
200	UXH 20947	P 44066	P 36376	5/16" DIA. GLASS FLOAT	P 38132	P 38132
250	UXJ 20947	P 44067	P 36376		P 38132	P 38132
300	UXK 20947	P 44068	P 38256	5/8" DIA. GLASS FLOAT	P 38132	P 38132
400	UXL 20947	P 44069	P 38256		P 38132	P 38132

PENWALT
WALLACE & TIERNAN
 DIVISION

FIG. 11-11 -
 ROTAMETER

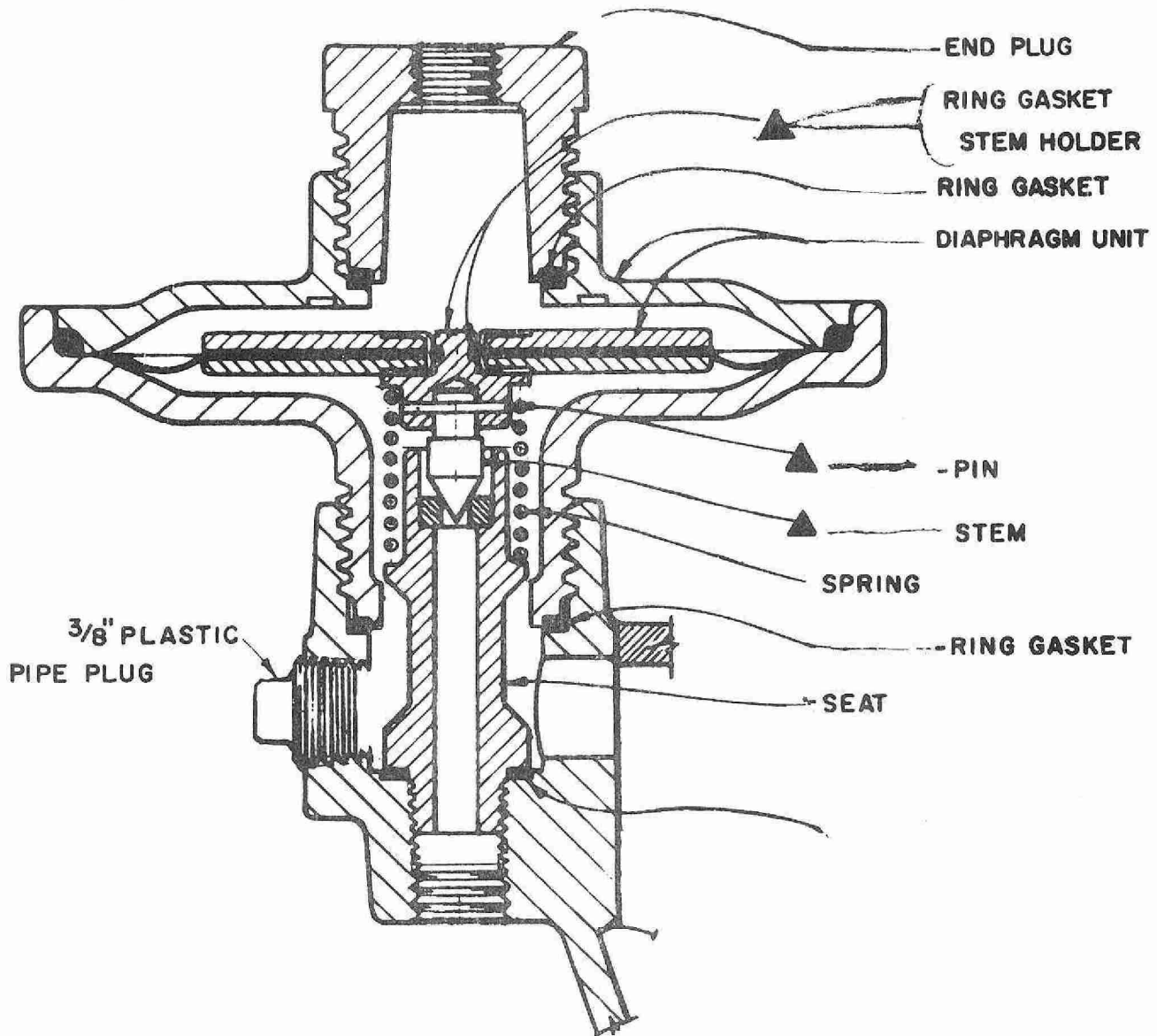
VACUUM & PRESSURE RELIEF VALVE

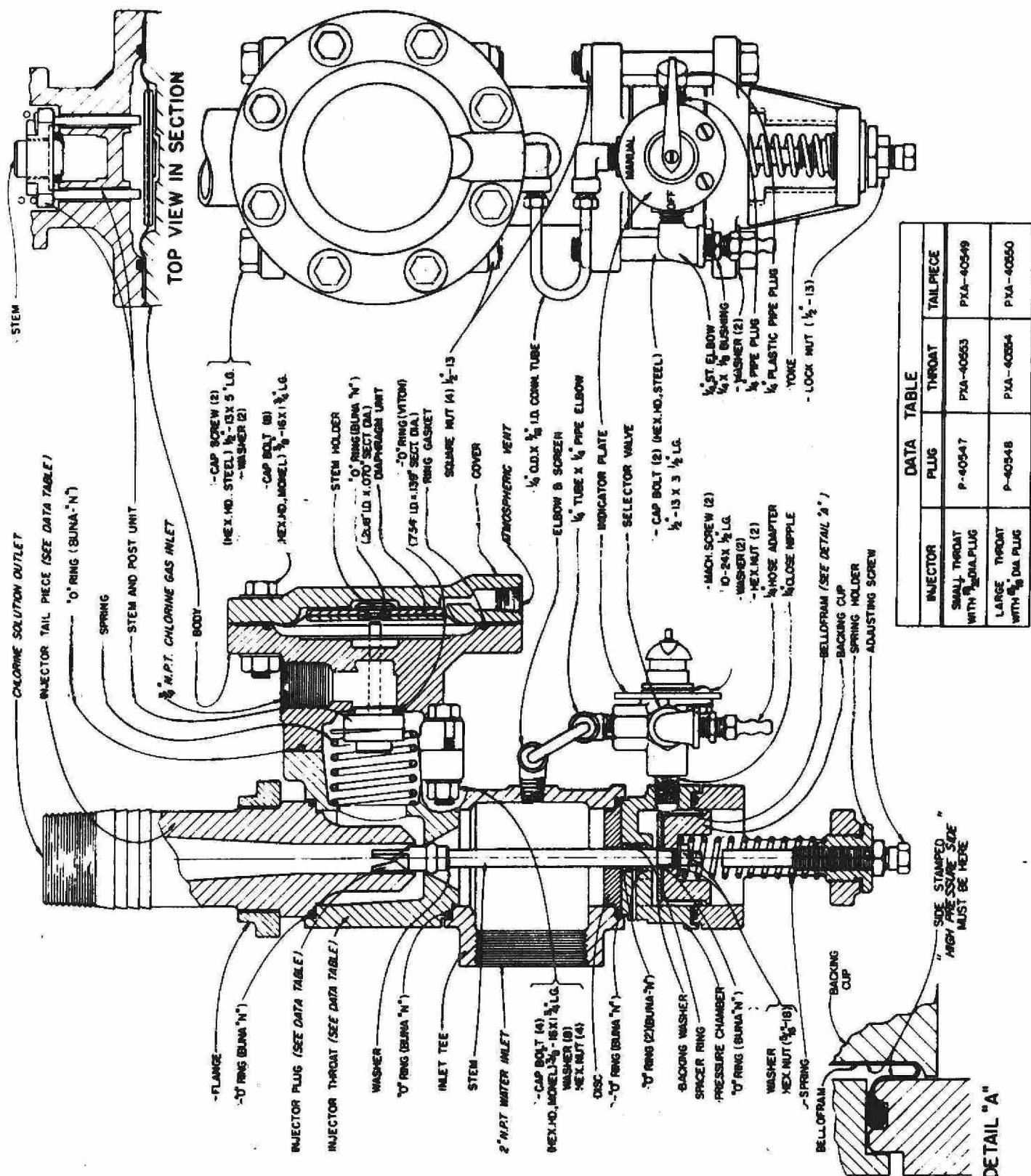
Used in 400 Lb. Capacity V-Notch Chlorinator



VACUUM REGULATING VALVE
Used in 400 Lb. Capacity V-Notch Chlorinator

PARTS





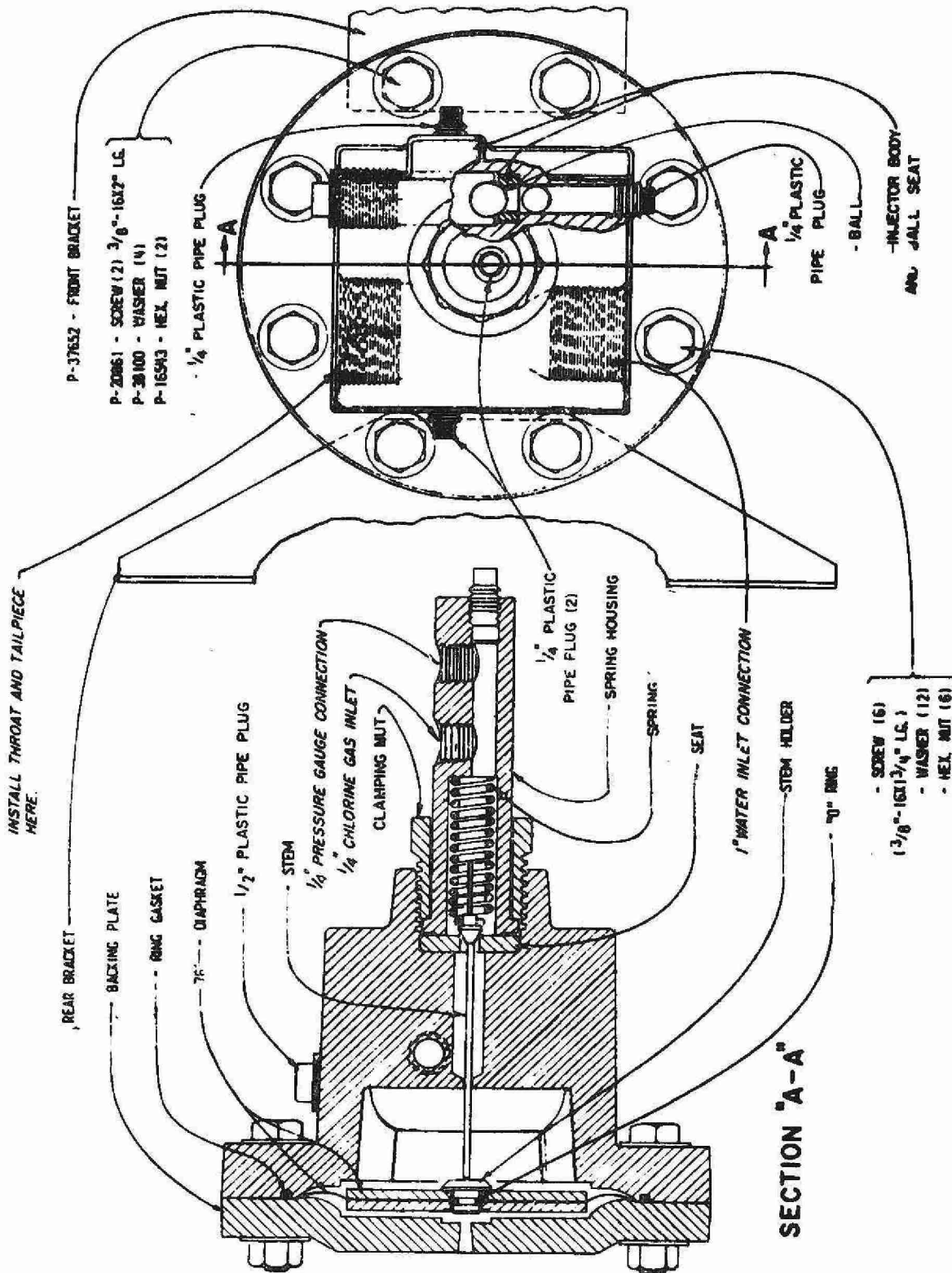
DATA TABLE			
INJECTOR	PLUG	THROAT	TAILPIECE
SMALL THROAT WITH 1/2" DIA. PLUG	P-40547	PXA-40553	PXA-40549
LARGE THROAT WITH 3/4" DIA. PLUG	P-40548	PXA-40554	PXA-40550

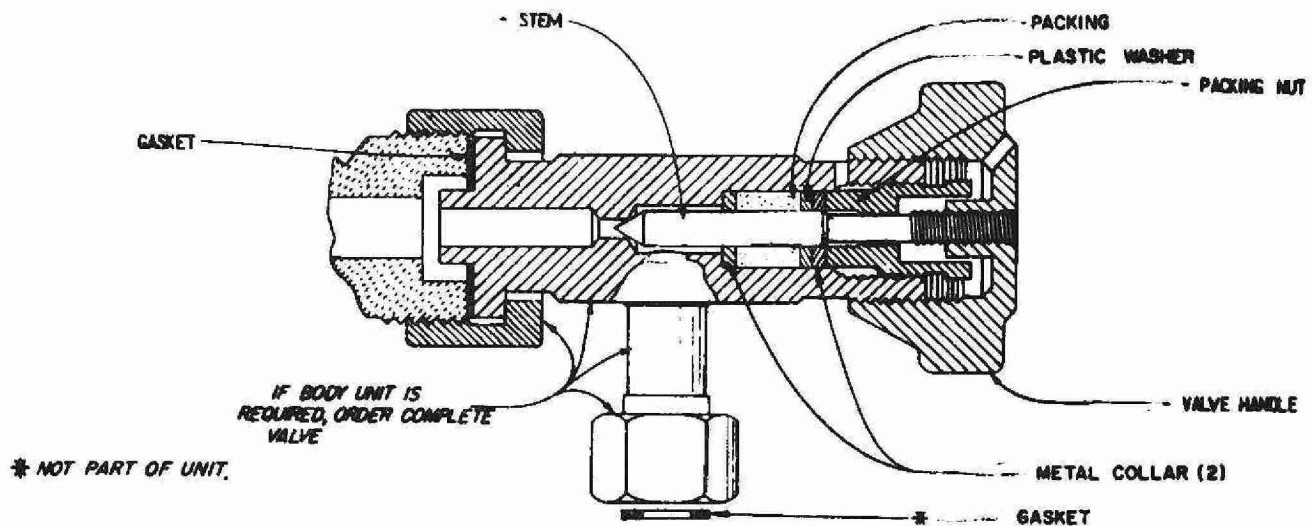
SMALL THROAT
LARGE THROAT



FIG. 11-14 INJECTOR
WITH PRESSURE OPERATED PLUG SHUT-OFF

Used in 400 Lb. Series V-800 Chlorinator

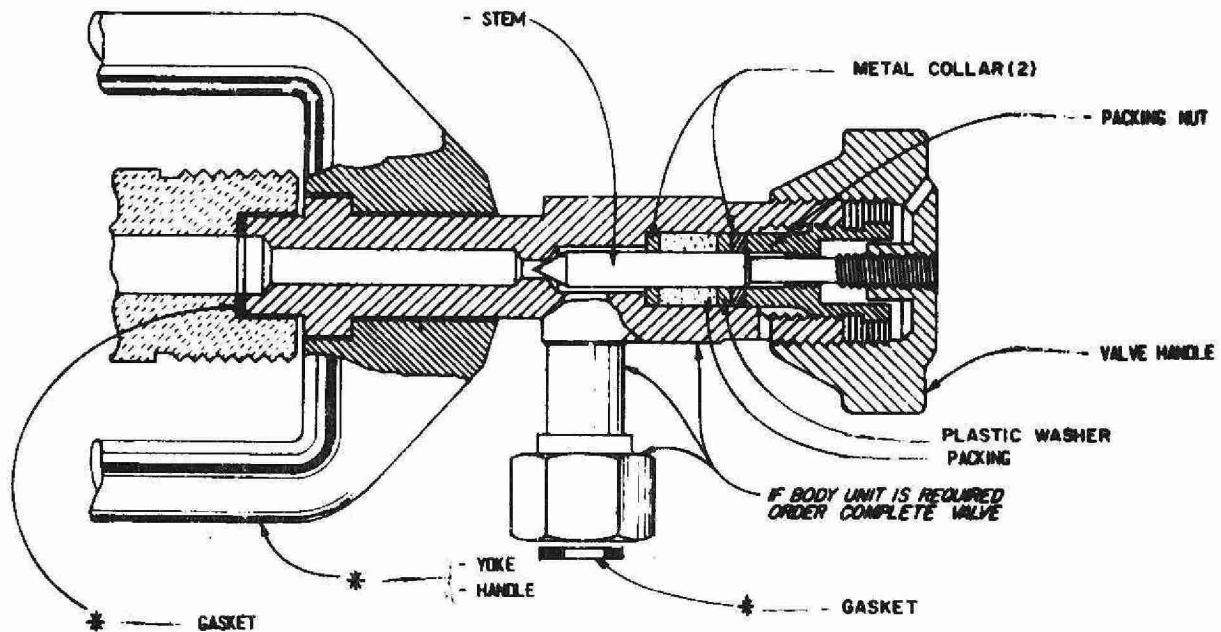




AUXILIARY CYLINDER VALVE-UNION TYPE

CHLORINE

SULFUR DIOXIDE



AUXILIARY CYLINDER VALVE-YOKE TYPE

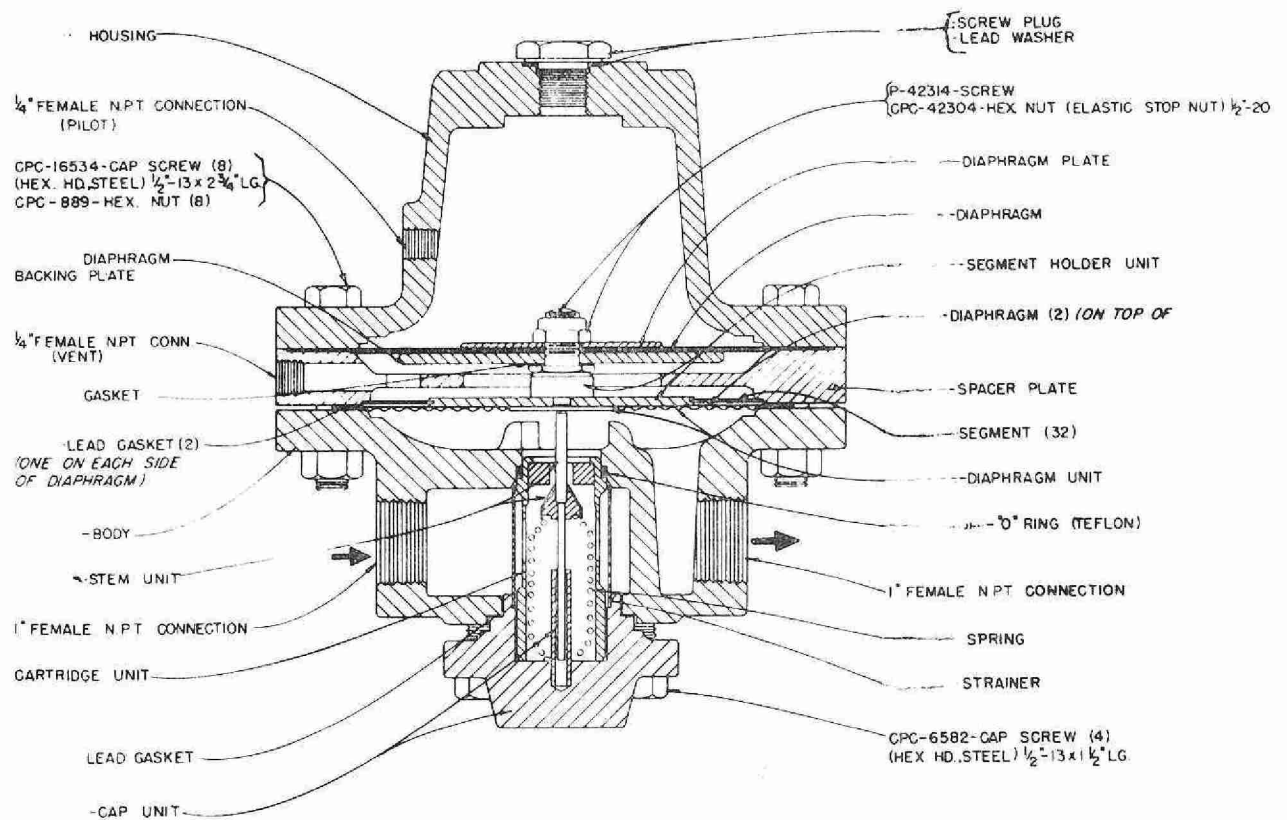
CHLORINE

SERIES A-786 CHLORINE SHUT-OFF & PRESSURE REDUCING VALVE

Pilot Control

PARTS

49856-1

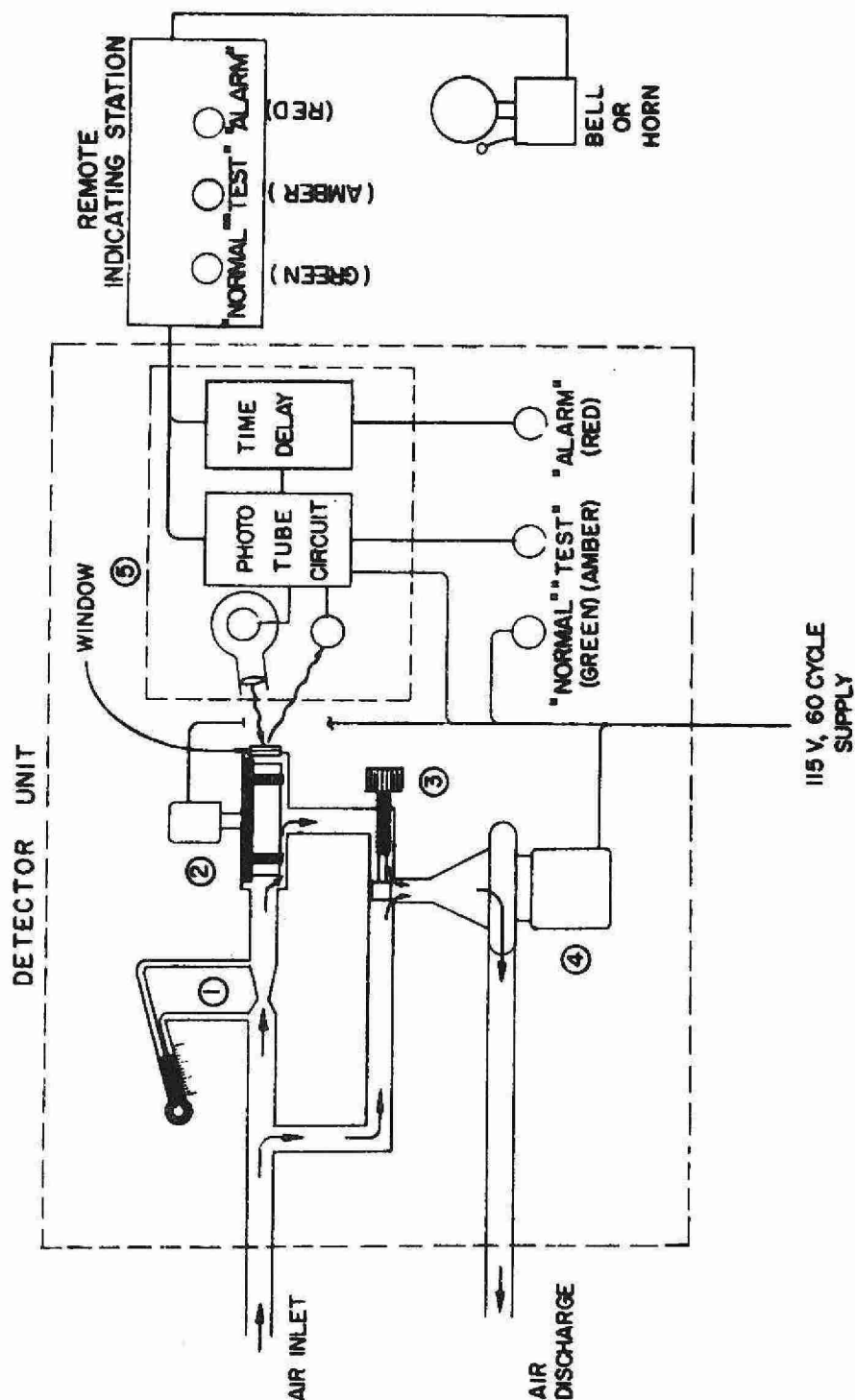


8000 LBS. MAX. CAP. }
2000 LBS. MAX. CAP. } 60 PS.I.

FIG. 11-17

CHLORINE SHUT-OFF AND PRESSURE
REDUCING VALVE





NOMENCLATURE

- ① AIR SAMPLE MEASURING ORIFICE & MANOMETER
- ② TEST CHAMBER WITH SENSITIVE TEST PAPER MOUNTED ON $\frac{1}{2}$ R.P.M. REVOLVING DRUM. TEST CHAMBER IS EQUIPPED WITH WINDOW FOR PHOTOTUBE AND DOOR FOR ACCESS TO TEST PAPER WHICH MUST BE CHANGED DAILY
- ③ AIR SAMPLE FLOW ADJUSTMENT SET FOR 0.3 TO 0.4 C.F.M. AIR FLOW THROUGH TEST CHAMBER.
- ④ BLOWER
- ⑤ PHOTOTUBE AMPLIFIER CHASSIS WITH LIGHT SOURCE AND TIME DELAY CIRCUITS.

SOLVAY CHLORINE DETECTOR MANUFACTURED BY WALLACE & TIERNAN INCORPORATED UNDER PATENT LICENSE FROM SOLVAY PROCESS DIVISION, ALLIED CHEMICAL AND DYE CORPORATION.



SOLVAY CHLORINE DETECTOR-SERIES A-689

FLOW DIAGRAM

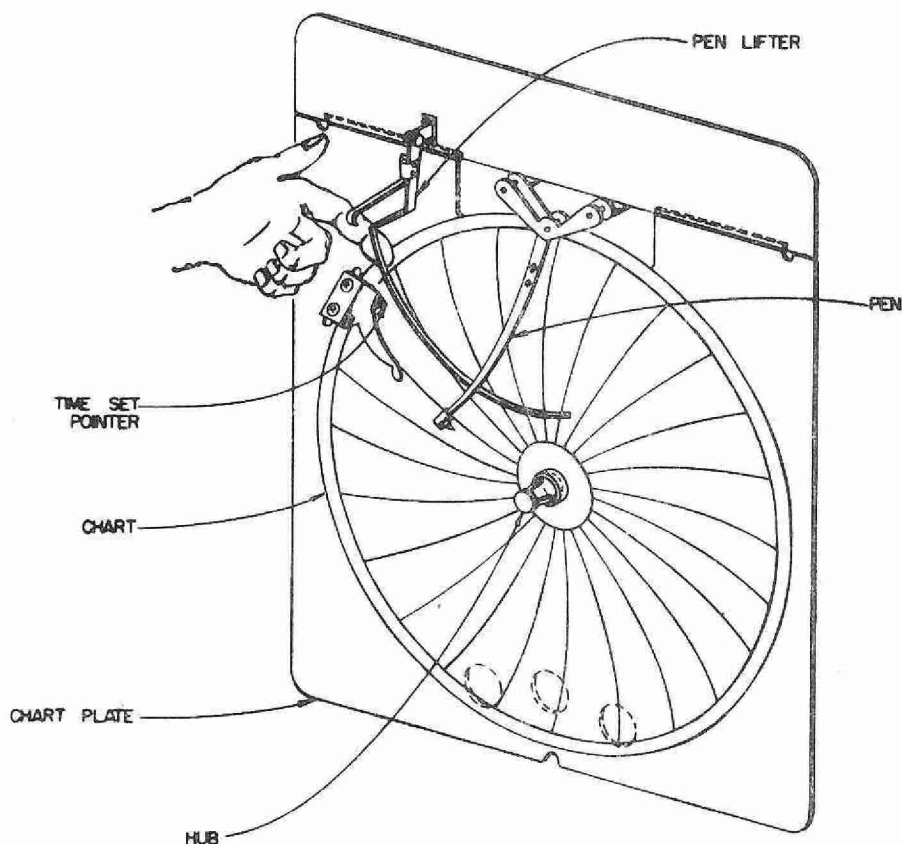
FIG. 11-18

ALARM SYSTEM USING SENSITIZED PAPER

① RAISE THE PEN LIFTER.

② PULL OUT ON THE CHART HUB. IT WILL COLLAPSE INTO ITSELF, LEAVING THE CHART FREE TO COME OFF. REMOVE THE CHART.

③ PUT ON A NEW CHART. PUSH IN ON THE CHART HUB SO THAT IT REENGAGES THE CHART.



④ ROTATE THE CHART HUB UNTIL THE PROPER TIME ARC IS INDICATED BY THE TIME SET POINTER. (NOTE--- DAY AND NIGHT SECTIONS ON THE CHART) THE TIME SET POINTER AND THE PEN POINT REGISTER ON THE SAME TIME ARC.



FIG. 11-19 CHART PLATE FEATURES
W & T RECORDERS

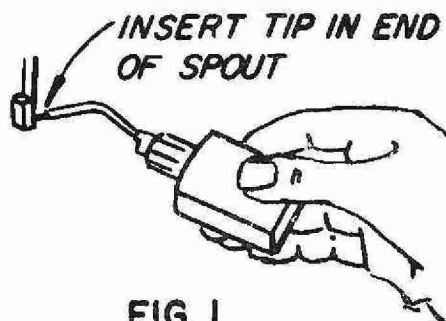


FIG. 1

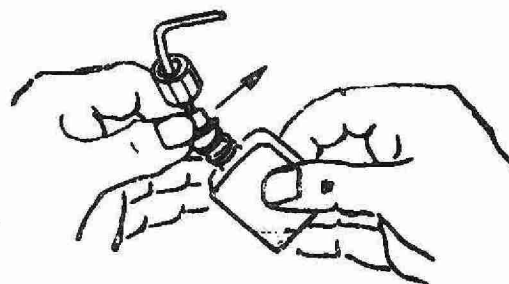


FIG. 2

TO INK A BOX PEN

Fill through the tip with the plastic ink bottle as shown in Fig. 1. This method of filling insures against air bubbles or other obstruction, and also primes the pen for quick starting. Put in no more ink than is estimated necessary. If there is doubt, a clean pen may be filled full the first time, but after that, the ink level should be kept as low as possible for cleanest lines and shortest drying time.

After using the plastic ink bottle, wipe the spout and replace it tightly in the sealing hole in the bottle cap.

STARTING A STUBBORN BOX PEN

If trouble is encountered in getting a box pen to ink, proceed as follows:

1. Remove the pen from the pen-arm. To do this, hold the pen-arm firmly and turn the pen in a counterclockwise direction permitting the clip on the back of the pen to be slipped off the pen-arm. Carefully withdraw the pen from the hole in the pen-arm.
2. Fill the pen nearly full of ink.
3. Grasp the pen reservoir with the thumb on top and forefinger beneath, and squeeze. Ink should start to ooze from the pen tip.

MAINTENANCE OF PEN

If a pen becomes dirty or begins to skip, clean it as described below. Detergent cleaners may be used, but every trace should be removed or severe feathering may result. Use only recorder ink. If long service wears a pen so that the line is too wide, replace the pen.

TO CLEAN A CLOGGED BOX PEN

1. Remove the box pen from its pen-arm. To do this, hold the pen-arm firmly and turn the pen in a counterclockwise direction. This permits the clip on the back of the pen to be slipped off the pen-arm. Carefully withdraw the pen from the hole in the pen arm.
2. Run a wire not larger than 0.005" diameter (B&S Gauge #36 or higher) or a Cleaning Wire, Part P-26488, through the tip to push out the dried ink.
3. Flush out by filling through the tip with the plastic ink bottle. Force through a surplus of ink into a tissue or paper towel to make sure the tip is clean.
4. Replace the pen.

TO REFILL THE PLASTIC INK BOTTLE

1. Pull out the spout and remove the screw cap as shown in Fig. 2.
2. Force the plug sideways, up and out. Don't try to pull it straight.
3. Fill to the line. Replace plug, cap, and spout.

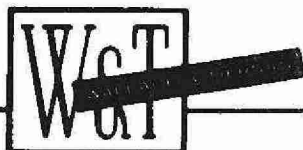


FIG. 11-20

INSTRUCTIONS FOR BOX PEN
W & T RECORDERS

NOTES

SUBJECT:

CHLORINATION EQUIPMENT

TOPIC: 12

START-UP

OBJECTIVES:

Trainee will be able to:

1. demonstrate start-up of chlorination system
2. perform the following steps in proper sequence:
 - (a) start vent fan
 - (b) open water lines
 - (c) check chlorinator vacuum
 - (d) open cylinder and valves
 - (e) check for leaks

START-UP DETAILS

1. Push button to start exhaust fan
 - (a) check louvers by visual observation - particularly in winter - to make sure they are open
 - (b) if there is ductwork for externally mounted fan, check for air flow by placing hand on end of duct for suction
 - (c) if there is no suction: (i) check to see if FAN is running; (ii) check ductwork for blockage.

NOTE: Exhaust system (fan and motor) MUST be in operation at all times during start-up.

2. Check visually the following pipelines and assure that equipment is hooked up:
 - (a) water lines:- check piping, elbows, valves, tees
 - (b) chlorination lines:- check piping, elbows, valves, tees
 - (c) vent lines:- be sure they are not plugged; vent lines must go to OUTSIDE atmosphere and should have a screen over the outlet.

- (d) automatic control lines (if any):- purge lines for possible moisture accumulation; in vacuum or pneumatic systems, purge all air from pressure differential systems
 - (e) electric lines:- make sure they are plugged into sockets
 - (f) new lines:- use litharge and glycerine or teflon tape on pipe joints.
3. Open Valve for water supply:
- (a) listen for water "whistling" through injector
 - (b) if no sound of water through injector, check water supply upstream.
4. Visually check the following for leaks:
- (a) valves
 - (b) elbows
 - (c) piping
 - (d) connections
 - (e) if no leaks are apparent, proceed to Step 5.
5. Check to see if vacuum is obtained:
- (a) observe the vacuum gauge on the chlorinator; it should indicate a *vacuum* reading
 - (b) if there is no vacuum, disconnect vacuum line at the injector
 - (c) place finger over injector connection for physical observation of vacuum (a suction would indicate there is vacuum).
6. Check and assure that *ALL* valves between the chlorinator and cylinder(s) are *OPEN*. Turn handle to open as indicated on valve.
- WHY? To ensure purging of system in case of leaks.
7. Turn chlorinator feed control to any open position.

8. Open cylinder valve:

- (a) simply "crack open" at beginning
- (b) if there is a severe leak in the system, it can be shut off faster than if the valve has to be turned a number of times for closure.

NOTE: Valve may be stiff to open. A quick, sharp blow may be required using butt of hand to open valve.

9. Turn chlorinator feed control to CLOSED position and observe chlorine pressure on gauge.

10. Check for chlorine leaks:

Open a concentrated ammonia bottle and check all joints and piping on chlorine line by holding bottle under or close to chlorine joints and piping (plastic squeeze bottle to exhaust ammonia vapour).

NOTE: A cloud of white smoke will indicate chlorine leak (caused by chlorine reacting with ammonia).

11. If any leaks found, immediately take the following steps:

- (a) shut cylinder valve
- (b) turn chlorinator feed control to MAXIMUM to purge system
- (c) leave chlorinator room and shut door until pressure gauge reads ZERO - usually a window in the wall allows you to see this from outside - and fumes are exhausted to atmosphere
- (d) when pressure gauge reads ZERO, proceed with corrective maintenance for leak(s)
(for example, this may be tightening of joint, replacing leaky gasket, replacing valve, or replacing split piece of pipe).

12. When leak has been repaired:
 - (a) fully open the chlorine cylinder valve (1½ turns)
 - (b) *RETURN TO STEP 4 AND REPEAT STEPS 4 TO 11.*
13. *If no leaks are found:*
Adjust the chlorinator setting to the desired rate.
14. If chlorination system is MANUAL, then check-out is complete.
15. If chlorination system is AUTOMATIC, check control components for proper functioning according to the manufacturer's specifications.

TABLE 12-1

SUMMARY: START-UP SEQUENCE

1. Start vent fan
2. Open water lines
3. Check chlorinator vacuum
4. Open cylinder and valves
5. Check for leaks

NOTES

NOTES

SUBJECT:
CHLORINATION EQUIPMENT

TOPIC: 13
NORMAL OPERATION OF
SYSTEMS

OBJECTIVES:

Trainee will describe the normal operation of the following chlorination systems:

1. Wallace & Tiernan (W&T) variable vacuum chlorinator.
2. Advance chlorinator.
3. Wallace & Tiernan (W&T) Bell Jar chlorinator.
4. BIF Industries chlorine feeder.
5. Fischer & Porter gas dispenser.

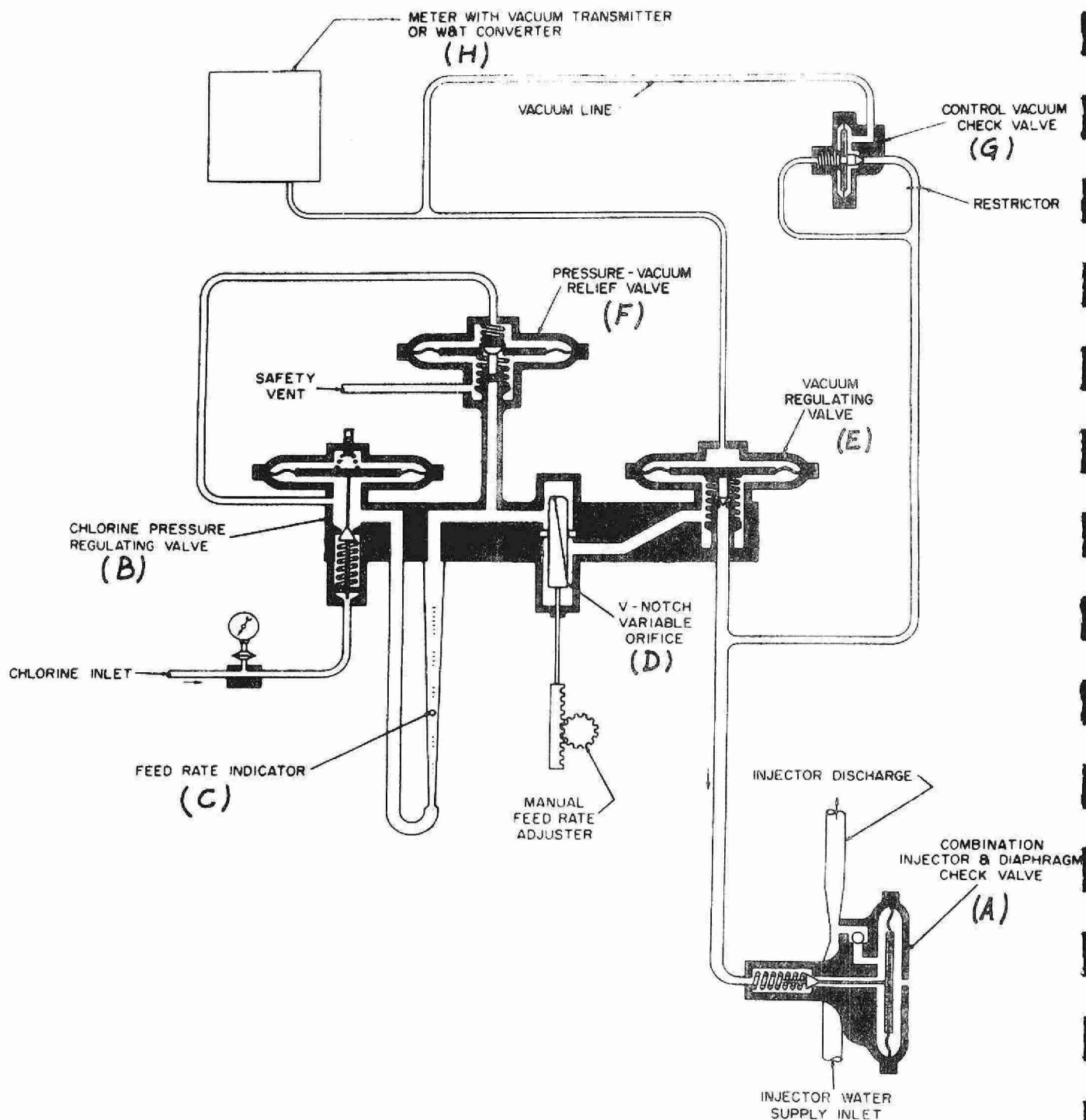
NORMAL OPERATION

1. Wallace & Tiernan (W&T) Variable Vacuum Chlorinator
(see Figure 13-1)

The chlorine gas is metered under a vacuum developed by an injector (A), and enters the chlorinator through a spring-loaded, diaphragm-operated pressure regulating valve (B). This valve maintains the proper operating vacuum ahead of the variable-orifice (D).

The gas then flows through a rate of feed indicator (C), and then through the variable-orifice (D). After leaving the orifice, the gas passes by a combination vacuum and pressure relief valve (F) through a vacuum regulating valve (E), which maintains the proper operating vacuum downstream of the variable-orifice.

The gas then passes to the injector (A) where it is dissolved in water. The resultant solution is discharged from the injector to the point of application via a solution tube or diffuser. The feed rate is adjusted by changing the area of the variable-orifice. This is accomplished by



FLOW DIAGRAM

FIG 13-1 VARIABLE VACUUM CONTROL
VACUUM FROM MAIN INJECTOR
V-NOTCH CHLORINATOR - SERIES A-731



positioning the control plug (V-Notch) within the seat.

The chlorine pressure regulating valve, which regulates the vacuum ahead of the metering orifice, also shuts off the chlorine if interruption of the injector water supply should destroy the operating vacuum, or a leak should develop in the vacuum line. Intermittent start-stop or program operation is obtained by interrupting the injector water supply.

2. Advance Chlorinator (see Figure 13-2)

Water passing through the injector under pressure at point (A) forms a vacuum and causes diaphragm (B) to be pulled away from the seat. This allows the vacuum to be transmitted to the rate valve (C). If the rate valve is open, the vacuum is transmitted through the rate indicator (D) to the regulating assembly (E). This pulls the regulating diaphragm in regulating assembly (E) towards the chlorine inlet valve (F), opening it and allowing chlorine gas to enter the system and pass through (E), (D), (C), (B) to (A) where it is mixed with water and discharged to the point of application.

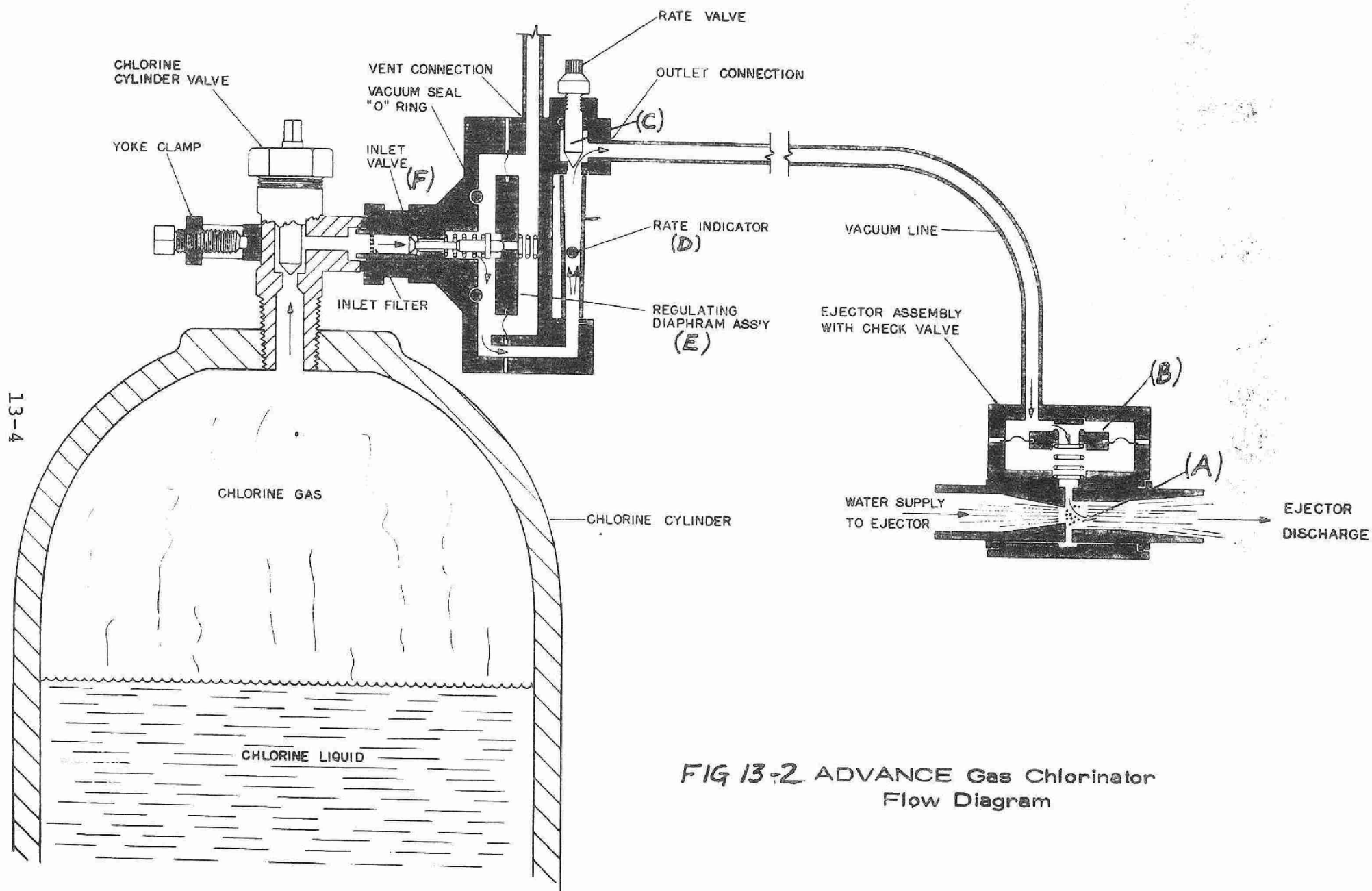
Vacuum failure allows the spring on the inlet valve (F) to move the diaphragm (E) away from the valve (F), closing valve (F) and stopping the flow of chlorine.

If valve (F) should "stick" in the open position, diaphragm (E) would be forced away from the stem of valve (F) and chlorine would pass through the centre of diaphragm (E) and out through the vent connection to the atmosphere.

3. Wallace & Tiernan (W&T) Bell Jar Chlorinator (see Figures 13-3 and 13-4)

The auxilliary water supply (A) on the bell jar chlorinator supplies the water for the tray, the collecting box and the air vacuum control assembly.

After passing through the strainer (B), the water enters the unit through the tray water control valve (C).



It passes to the tray (D), filling the tray to the top of the tray overflow (E).

From the tray overflow, the water fills up the U-tube manifold (F), and thus the air vacuum control assembly until it flows out through the aspirator tube (G) and overflows into the collecting box (H).

The end of the overflow tube and the aspirator tube are below the level of the weir (I) over which the water must flow to drain, thereby providing a seal for the vacuum control assembly (J).

The aspirator assembly pulls air from the control assembly by forming a vortex, thus giving a vacuum which controls the level of water in the vacuum control chamber (see above), and is transmitted through the U-tube manifold to the injector suction chamber (K).

The vacuum in the control chamber is controlled by the depth to which the vacuum adjusting tube (L) is lowered in the chamber. This allows more or less water to pass out of the suction chamber to the injector to satisfy the injector vacuum.

The resulting vacuum is then transmitted through the orifice meter (M) to the inside of the bell jar and is indicated on the meter.

The vacuum in the bell jar pulls the water up until it raises the float on the chlorine pressure reducing valve (N), lifting the needle valve off its seat and allowing chlorine to enter the bell jar. The greater the controlled vacuum, the higher the float is raised. More chlorine then enters the unit and is pulled through the orifice meter to the injector.

Adjustments for W&T Bell Jar Chlorinator

Tray Water Diverson Valve (O)

Normally set to split the flow between the two chambers. When water is extremely cold it is advisable to direct

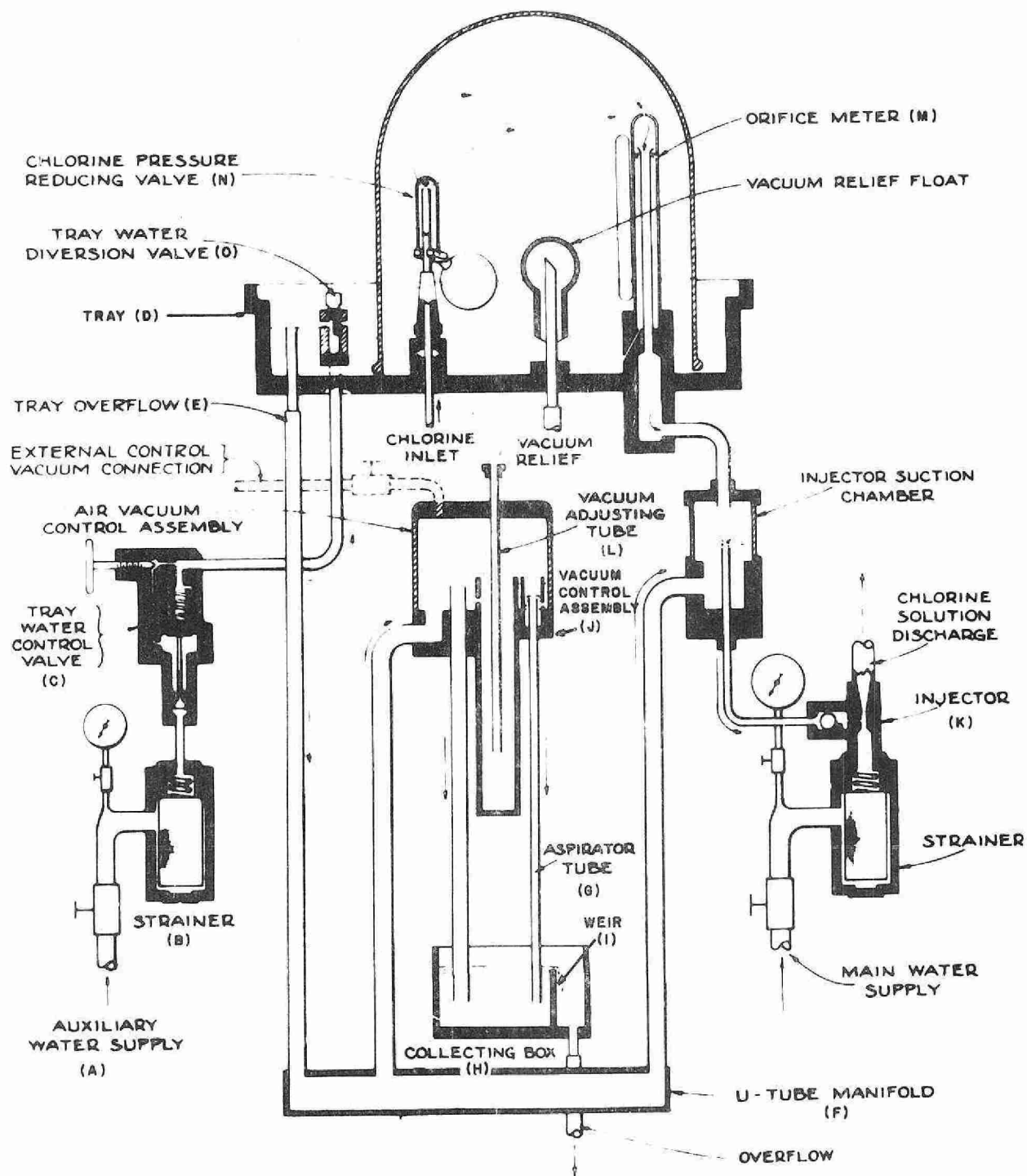


FIGURE 13-3

all the water AWAY from the bell jar. This allows the water within the bell jar to warm up and helps prevent icing of the chlorine pressure reducing valve.

Chlorine Pressure Reducing Valve (CPRV) (N) is adjustable vertically. This is to adjust the water level in the bell jar to the zero line on the orifice meter (usually even with the top of the tray).

Tray Water Control Valve (C)

With the vacuum adjusting tube lifted clear of the water in the control assembly, and the machine thus using the maximum amount of water through the injector suction tube, adjust the control valve so that there is a small flow of water over the weir of the collecting box.

Safety Controls for W&T Bell Jar Chlorinator

Injector failure causes loss of vacuum in the bell jar, thus allowing the water level to drop, lowering the ball on the CPRV and closing off the chlorine.

Chlorine supply failure causes the water level to increase approximately 1½" in the bell jar, pulling air from the atmosphere into the bell jar from under the vacuum relief float.

Leaking CPRV forces water inside the bell jar down to a level approximately one inch below the water level outside the bell jar and thus below the bottom of the vacuum relief float. This allows the gas to pass inside the float and out to the atmosphere.

4. BIF Industries Chlorine Feeder (see Figure 13-5)

Water pressure passing through the injector at point (A) forms a vacuum which draws the diaphragm away from its seat in the check valve (B) and transmits the

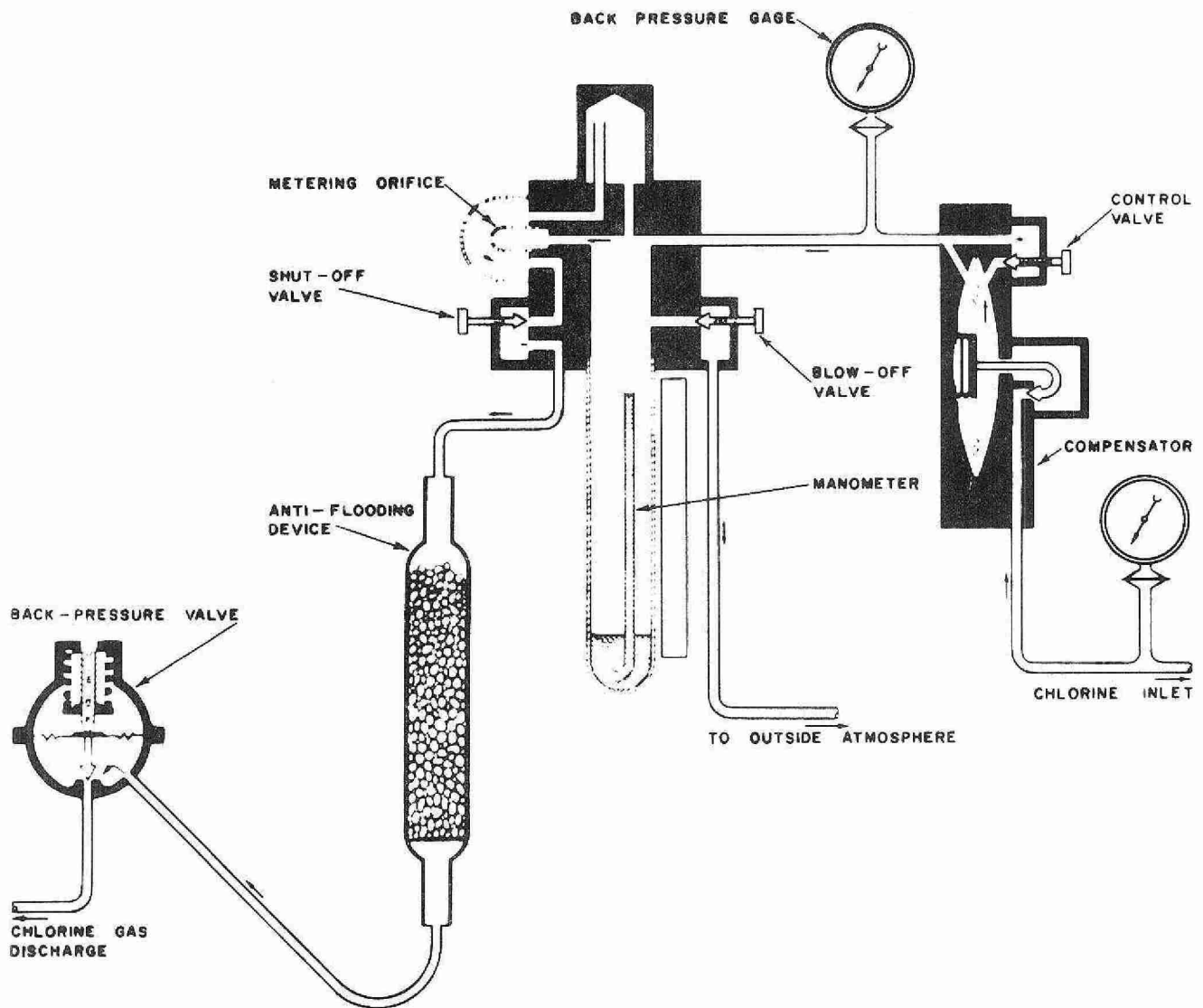


FIGURE 13-4

the vacuum to the differential pressure regulator (C). The vacuum opens valve (C) and allows transmission of the vacuum to the feed rate adjustment valve (D).

Vacuum is then transmitted to the rotameter (E) and to the inlet regulator (F) to open the inlet valve (G) and allow the gas to flow back to point (A) for discharge into the system.

Failure of the injector vacuum allows the inlet valve (G) to close and stop the flow of chlorine through the system. However, should valve (G) fail to close, the resulting pressure would force the diaphragm in the inlet regulator (F) away from its seat, allowing the gas to escape through the vent to outdoors.

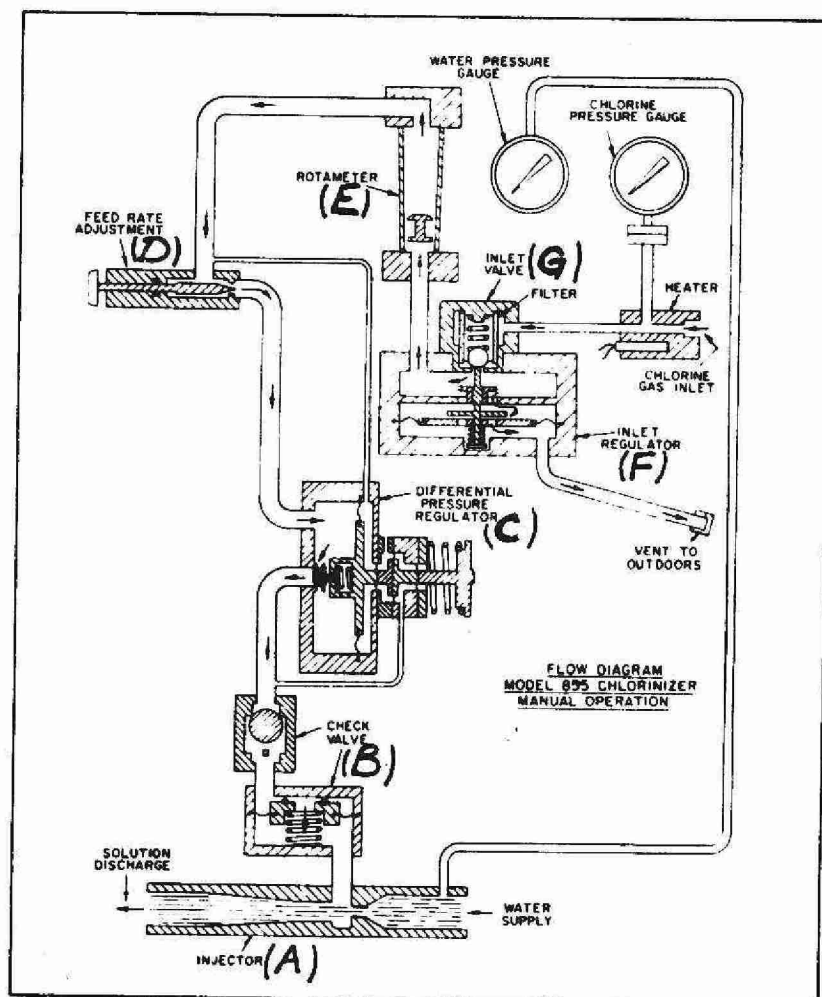


Fig. 13-5 - BIF Chlorine Feeder

LEGEND

* - OPTIONAL EQUIPMENT, FURNISHED IF SPECIFIED.

** - FIXED RANGE SAFETY STACK REGULATOR FURNISHED WHEN MANUAL RATE VALVE IS SPECIFIED.

† - COMPONENTS ASSOCIATED WITH THE ADJUSTABLE RANGE SAFETY STACK REGULATOR ONLY. FURNISHED WHEN FLOWRATOR VALVE IS SPECIFIED.

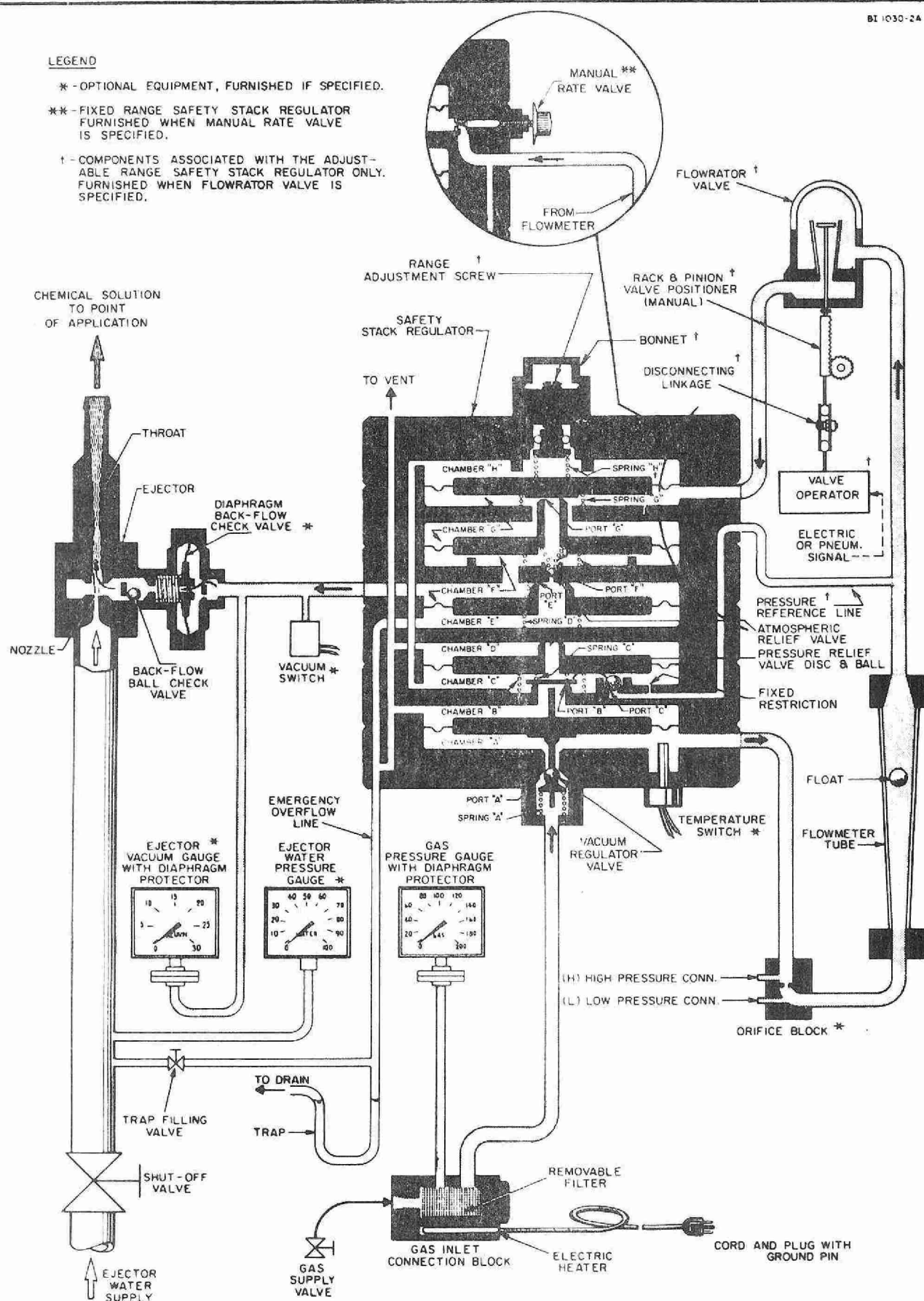


FIG 13-6 FUNCTIONAL SCHEMATIC OF THE SERIES 70_3400 GAS DISPENSER WITH FIXED OR ADJUSTABLE RANGE SAFETY STACK REGULATOR

Courtesy Fischer & Porter

5. Fischer & Porter Gas Dispenser (see Figure 13-6)

I. General Description

The Series 70_3400 Gas Dispenser Safety Stack Regulator consists of the vacuum regulator, the differential pressure regulator, and the components that comprise the safety features, all housed in a single regulator stack. Whether the Safety Stack Regulator has a fixed range or an adjustable range, the operation of these parts is identical.

The vacuum regulator admits gas from the pressurized gas supply and reduces the pressure of the gas from supply pressure to a constant vacuum. The differential pressure regulator maintains a constant pressure drop across the orifice of the rate valve to keep the flow of the gas constant. In the fixed range regulator the pressure drop is factory set and fixed; the adjustable range regulator provides for the manual adjustment of the pressure drop to allow the control range of the rate valve to be varied. The safety features are incorporated to prevent damage to equipment and danger to operating personnel in the event of abnormal conditions within the Gas Dispenser or associated equipment. The vacuum regulator, the differential pressure regulator, and the safety features are described in detail in the following sections.

II. Functional Description of the Regulators

Refer to Fig 13-6 to supplement the following functional description. The description assumes that the rate valve (the manual rate valve or the Flow-rator" valve, whichever is present) is partially open, that the gas supply containers have been connected and the gas supply valves are open, and that the ejector water supply valve has just been opened.

As the water, under pressure, is forced through the ejector nozzle, a vacuum is created within the throat of the ejector due to the high velocity of the water as it leaves the nozzle. This vacuum builds up in the gas line between the ejector and the safety stack regulator and in the chamber designated "F" in Fig 13-6. The vacuum in chamber "F" pulls diaphragm "D" down against its stops, opening port "G". At the same time spring "F" is compressed against the ball to seal port "F", the

atmospheric relief valve. The vacuum builds up in chamber "G" and back through the rate valve, the flowmeter, the orifice block, if present, and chamber "A". Chamber "A", diaphragm "A", port "A", and spring "A" make up the vacuum regulator.

The vacuum in chamber "A" pulls diaphragm "A" downward, moving the plug of the vacuum regulator valve off its seat. Diaphragm "A" is free to move since chamber "B" above the diaphragm is open to the atmosphere through the vent line. When port "A" of the vacuum regulator valve is opened, gas flows from the gas supply containers (through the gas inlet connection block) and enters chamber "A". As the gas passes through the regulator valve it is expanded in volume and its pressure is reduced from the pressure of the supply containers to a vacuum level.

The vacuum level in chamber "A" is unaffected by the pressure level of the supply containers and is maintained constant by the throttling action of the vacuum regulator valve as controlled by the position of diaphragm "A". The downward pull of the vacuum on diaphragm "A" is constantly opposed by spring "A" which exerts a virtually constant force in the upward direction. The diaphragm is in equilibrium (and the correct throttling action is provided) when the vacuum in chamber "A" exactly balances the force of spring "A".

The gas is drawn from chamber "A" through the orifice block, if present, through the flowmeter where the flow rate is measured and indicated, and through the orifice of the rate valve which provides for manual or automatic control of gas flow rate. The gas flows into chamber "G", through port "G" to chamber "F", and finally through the back-flow check valves into the ejector. In the throat of the ejector the gas is thoroughly mixed with the ejector water to form a chemical solution which is then transported to the point of application.

Immediately upstream of the rate valve, a separate "pressure reference line" is branched off from the main gas flow. This static line transmits the vacuum existing upstream of the rate valve through the fixed restriction and chamber "C" to chamber "H" above diaphragm "E". Chamber "G" is connected to the opposite side of the rate valve so that the vacuum downstream of the valve exists on the underside of diaphragm "E". Spring "G" exerts an unbalancing force on this diaphragm (virtually constant for the small displacements of the diaphragm) that tends to open port "G". This causes

more gas to flow through the port and, therefore, through the rate valve. This increases the pressure drop across the orifice of the rate valve; the increased differential also exists across diaphragm "E" and pulls the diaphragm downward, tending to close port "G" and throttle the flow of gas.

When precisely enough gas flows through port "G" so that the spring tension is exactly opposed by the differential acting on diaphragm "E", the diaphragm is restored to equilibrium. Thus, chamber "H", diaphragm "E", chamber "G", spring "G", and port "G" make up the differential pressure regulator that maintains a constant pressure drop across the orifice of the rate valve. This keeps the flow of gas through the rate valve (and, therefore, through the Gas Dispenser) constant for each valve setting and compensates for any variations that may occur in the vacuum level at the ejector.

As shown in Fig 13-6, the adjustable range safety stack regulator includes an additional spring ("H") and a range adjustment screw. The tension of spring "H", which can be manually adjusted with the range adjustment screw, partially cancels the tension of spring "G". In effect, this allows the tension of the differential pressure regulator spring ("G") to be adjusted so that the pressure differential across the rate valve can be varied. Therefore, the flow rate through the valve can be adjusted (without changing the valve setting) until the gas is flowing at 100% of Dispenser capacity when the rate valve is fully open.

NOTES

NOTES

SUBJECT:

CHLORINATION EQUIPMENT

TOPIC: 14

SHUT-DOWN

OBJECTIVES:

Trainee will be able to:

1. demonstrate shut-down of chlorination
2. perform the following steps in proper sequence:
 - a. start vent fan
 - b. shut off cylinder(s)
 - c. check chlorine pressure
 - d. shut chlorine line valves
 - e. shut water valves

SHUT-DOWN DETAILS

1. Push button to start exhaust fan:

- (a) check louvers by visual observation - particularly in winter - to make sure they are open
- (b) if there is ductwork for externally mounted fan, check for air flow by placing hand on end of duct for suction
- (c) if there is no suction: (i) check to see if FAN is running; (ii) check ductwork for blockage.

NOTE: Exhaust system (fan and motor) MUST be in operation at all times during shut-down.

2. Shut OFF chlorine at cylinder or manifold as required:

- (a) check pressure gauge
- (b) make sure pressure gauge reading drops to ZERO.

3. Beginning at cylinder(s):

- (a) shut off ALL valves as you move towards chlorinator
- (b) do NOT shut off chlorinator YET.

4. Allow chlorinator to continue operating for approximately 15 minutes, without chlorine entering it.

WHY? *To ensure complete purging of system.*

5. Shut off water supply (injector) valve.
6. Shut off automatic control equipment, such as electric plug positioner, variable vacuum valve, or pneumatic valves.
7. If system is shut-down longer than 10 minutes *ALL* chlorine lines must be sealed from atmosphere.

WHY? *Chlorine mixing with moisture from the air will cause corrosion of pipe.*

TABLE 14-1

SHUT-DOWN SEQUENCE

1. Start vent fan
2. Shut off cylinder(s)
3. Check chlorine pressure
4. Shut chlorine line valves
5. Shut water valves

NOTES

NOTES

SUBJECT:

CHLORINATION EQUIPMENT

TOPIC: 15

MAINTENANCE

OBJECTIVES:

Trainee will be able to:

1. recognize mechanical malfunctions of:
2. describe immediate and/or long-term operational adjustments for:
3. name most probable component(s) needing repair or replacement for:
4. list in order of probability, from highest to lowest, most probable causes of malfunction for:
 - a. vent fan
 - b. injector
 - c. rate controller
 - d. rotameter
 - e. pressure and vacuum gauges
 - f. evaporator
 - g. alarm system
 - h. recording instrument
5. describe a daily, weekly and annual maintenance schedule.

EQUIPMENT

1. Vent Fan (see Fig. 11-1)

(a) Inspect motor:

- (i) check to see if shaft turns when energized
- (ii) if shaft does not turn, check if relay is on
- (iii) check if fuses are burnt and replace
- (iv) check heater
- (v) bearing or fan blade may be seized; disconnect power and proceed to find and correct problem
- (vi) if motor still not running, have it repaired or changed.

(b) Inspect fan blades:

- (i) be sure blades are free to turn
- (ii) check to see if blades are tight on shaft
- (iii) stop fan and assure blades are symmetrical
AND BALANCED by turning blades. If balanced,
blades will remain in any position.

(c) Inspect louvers:

- (i) be sure they open when required
- (ii) BE SURE NO DEBRIS IS PILED AGAINST UNIT.

2. Injector (see Fig. 11-8)

- (a) disassemble injector
- (b) check nozzle (throat) - 70% of problems - for plugging
by rust, or accumulation of dirt. Remove blockage
- (c) check tailway (discharge section) of injector for
abrasion (particularly true when on wells or where
some fine sand may be in suspension in water)
- (d) inspect ball check - SHOULD BE CLEAN AND FREE TO MOVE
- (e) inspect diaphragm for breakage. If broken, replace
- (f) visually inspect for leaks at joints
- (g) replace gaskets where required
- (h) tighten bolts where required
- (i) check springs for corrosion

3. Rate Controller (see Fig. 11-5)

- (a) inspect for possible linkage disconnection or rack
and pinion failure
- (b) manually operate controller to see if gas flow can
be regulated (increased or decreased)
- (c) check all seal gaskets and replace if necessary
- (d) check for foreign material on stem and seat
- (e) check automatic control by using Manufacturer's
Procedures Manual

(If chlorinator functioned satisfactorily on manual control, problem may be in the automatic control).

4. Rotameter (see Fig. 15-1 and Fig. 11-3)

- (a) visually inspect for build-up of foreign material inside rotameter and/or on the FLOAT
- (b) determine if rotameter is properly seated at top and bottom
- (c) inspect gaskets for defects (cracked or flattened). Replace if required.

5. Pressure and Vacuum Gauges

- (a) check for leaks
- (b) open line at joint and check for plugging
- (c) open gauge by removing glass, dial face and check if gearing is meshing properly

NOTE: Do NOT disconnect gauge from diaphragm assembly.

- (d) check bellows for possible rupture (oil at connection to tube).

6. Evaporator (see Fig. 11-9)

- (a) check temperature:
 - (i) if it is *HIGH* (approx. 160 deg.), shut off power supply to heaters
 - (ii) if it is *LOW* (approx. 120 deg.), check to see if heater is functioning, or if it is burnt out
- (b) check water level: *SHOULD BE WITHIN LIMITS SET BY MANUFACTURER*
 - (i) if *LOW*, check "make-up" valve. If valve is manual, open it. If valve is automatic, it may need repair. Low level may also be caused by evaporation. Pour light film of oil over surface to prevent evaporation
 - (ii) if *HIGH* drain water to level required and be sure

"make-up" valve is closed. (Leaking make-up valve causes high level).

(c) Check pressure:

- (i) if pressure is *HIGH*, check high temperature control to see if it is functioning, because high pressure is caused by high temperature
- (ii) if pressure is *LOW*, check chlorine supply which may be low. Increase chlorine supply. Change cylinder if necessary, check to see if thermostat is turning on heaters at *LOW* temperature
- (iii) check incoming liquid pressure and assure it is at proper level.

7. Alarm System

(a) Chlorinator Malfunction:

check functioning of system by:

- (i) turning off water to injector and waiting for alarm to sound (approx. 15-20 seconds); when alarm rings, turn water on again; if alarm does NOT sound, check linkage to switch, then check diaphragm
- (ii) turning off chlorine gas supply and waiting for alarm to sound; when alarm rings, turn chlorine supply on again; if alarm does NOT sound, check linkage to switch, or positioning of switch

(b) For Atmosphere in Chlorination Room:

- (i) if alarm system uses sensitive paper, block light to sensitive paper; listen for alarm to sound; remove object blocking light

*NOTE: Be sure sensitive paper is not too aged, as it loses its sensitivity to light with time.
SHELF LIFE - 4-6 MONTHS (IF KEPT AWAY FROM LIGHT)*

- (ii) systems using a cell assembly can be tested by holding a beaker of Javex near the air intake. This should activate the alarm. System should slowly return to normal operation after removal of beaker.

8. Recording Instruments: Charts and Pens

(a) Charts (see Fig. 15-2)

- (i) visually inspect to see if chart is bent
- (ii) visually inspect to see if chart is misaligned
- (iii) visually inspect to see if chart is jamming as it rotates

(b) Pen (does not print) (see Fig. 15-3)

- (i) inspect ink-well to see if ink supply is gone
- (ii) fill well as required
- (iii) capillary tube may be plugged - run fine wire (4/1000 inch) through tube to remove foreign material
- (iv) pen not touching paper. Check arm of pen to see if it is bent.

MAINTENANCE SCHEDULE

Daily

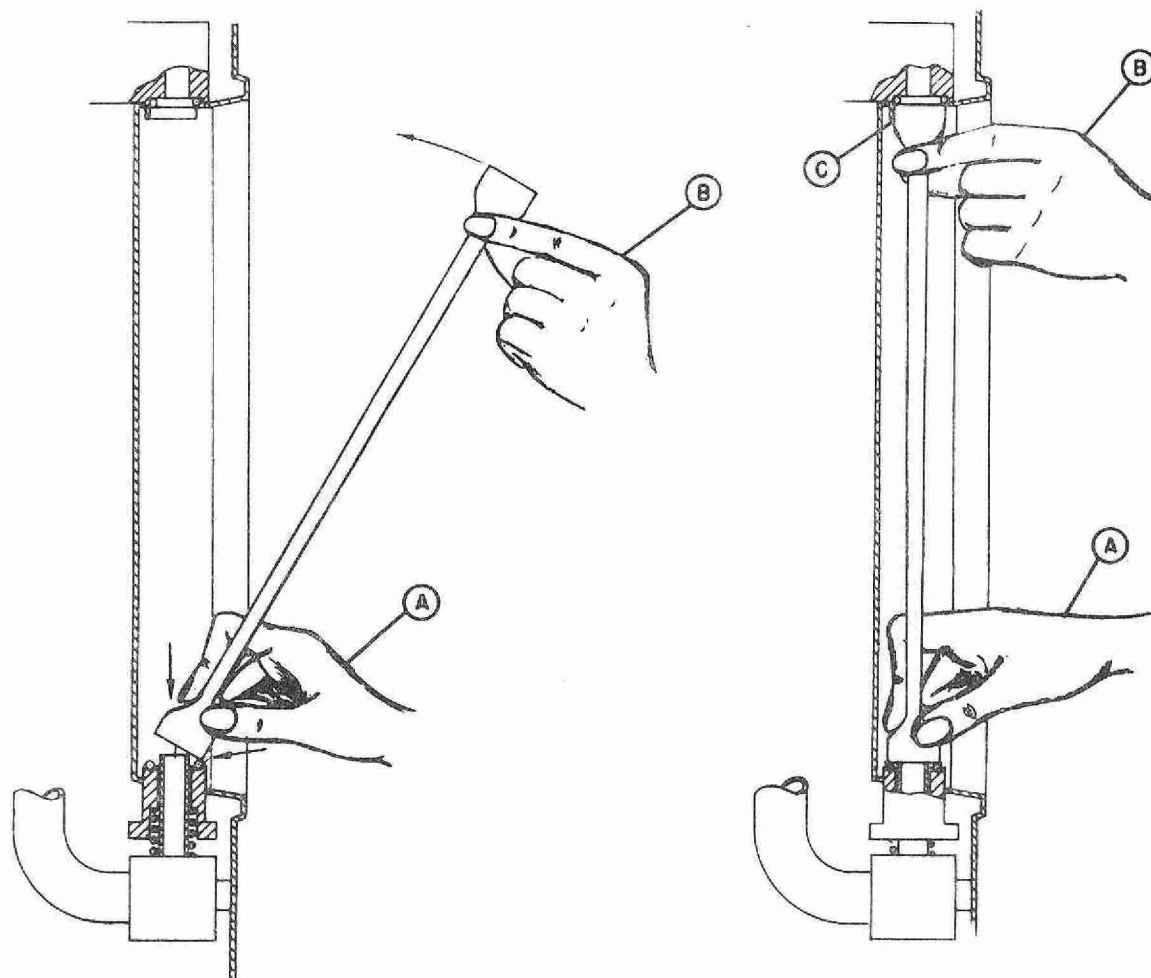
1. See that automatic controls start and stop properly.
2. Make sure that sufficient solution is on hand.
3. Check pump and piping for leaks.

Weekly

1. Remove and clean glass and plastic parts of sight-feed indicator.
2. Remove white coating caused by lime deposit by soaking in 5 percent muratic acid.
3. Clean and flush solution tank.
4. Clean screens and strainers on water lines.
5. Operate all shut-off and rate-control valves.

Annually

1. Remove, inspect and replace parts and packing as required.
2. Clean all orifice plates, needle valves, screens in water meters, etc.
3. Touch up all metal parts with paint.



TO INSTALL ROTAMETER--

1. LUBRICATE BOTTOM "O" RING ONLY WITH A LIGHT FILM OF SILICONE GREASE.
2. POSITION "O" RINGS AS INDICATED. INSERT FLOAT AND STOPS IN ROTAMETER TUBE.
3. GRASP ROTAMETER BY THE TWO ENDS.
4. GUIDE LOWER END OF ROTAMETER WITH HAND "A" TO LOCATE ON "O" RING.
5. EXERT DOWNWARD FORCE WITH HAND "A" TO COMPRESS SPRING AND USE TWO FINGERS OF HAND "B" TO GUIDE TOP OF ROTAMETER INTO POSITION. ROTAMETER MUST TOUCH AT POINT "C" TO INSURE SEATING ON UPPER "O" RING.
6. RELEASE DOWNWARD FORCE ON SPRING.

TO REMOVE ROTAMETER--

1. EXERT DOWNWARD FORCE ON LOWER BELL OF ROTAMETER WITH HAND "A."
2. USE TWO FINGERS OF HAND "B" TO SWING TOP OF ROTAMETER OUTWARD.
3. LIFT ROTAMETER.

READ SCALE OPPOSITE CENTER OF BALL.

PENWALT-

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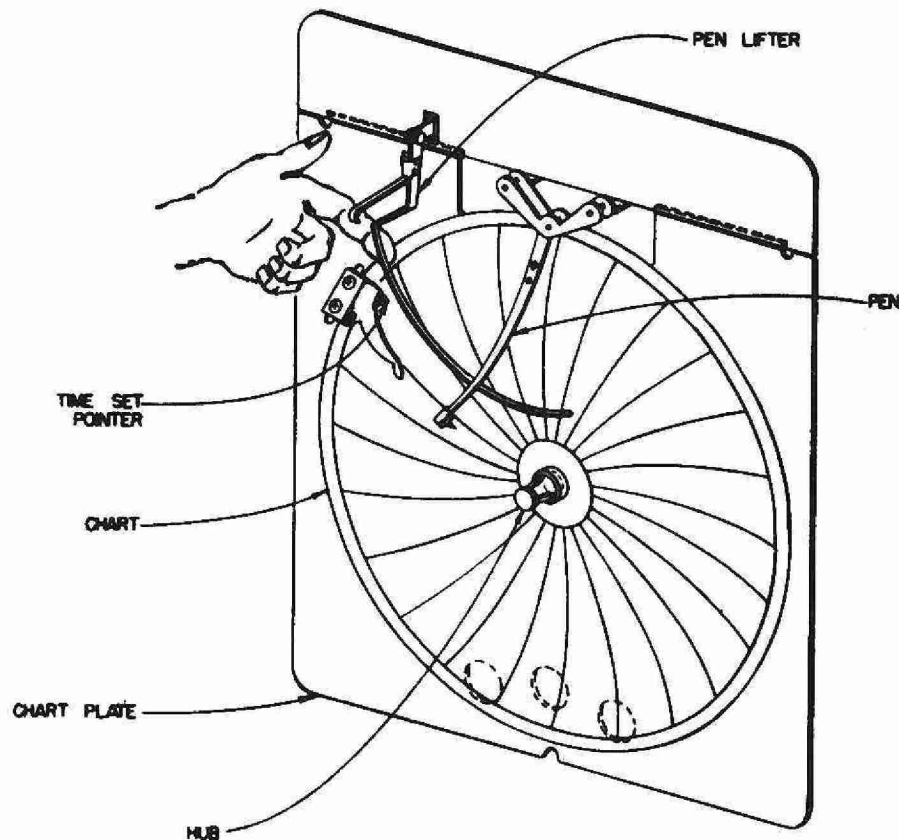
FIG. 15-1

INSTALLATION OF ROTAMETER

① RAISE THE PEN LIFTER.

② PULL OUT ON THE CHART HUB. IT WILL COLLAPSE INTO ITSELF, LEAVING THE CHART FREE TO COME OFF. REMOVE THE CHART.

③ PUT ON A NEW CHART. PUSH IN ON THE CHART HUB SO THAT IT REENGAGES THE CHART.



④ ROTATE THE CHART HUB UNTIL THE PROPER TIME ARC IS INDICATED BY THE TIME SET POINTER. (NOTE--- DAY AND NIGHT SECTIONS ON THE CHART) THE TIME SET POINTER AND THE PEN POINT REGISTER ON THE SAME TIME ARC.



FIG. 15-2

CHART PLATE FEATURES
W & T RECORDERS

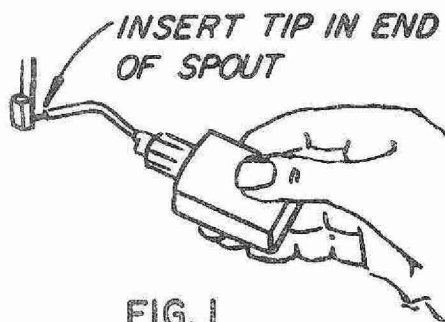


FIG. 1

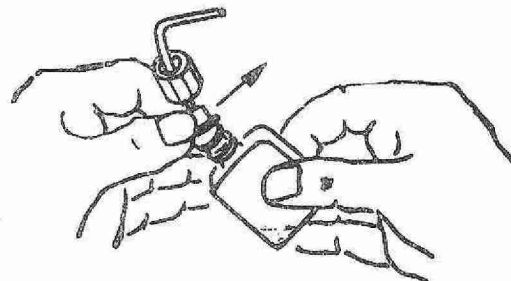


FIG. 2

TO INK A BOX PEN

Fill through the tip with the plastic ink bottle as shown in Fig. 1. This method of filling insures against air bubbles or other obstruction, and also primes the pen for quick starting. Put in no more ink than is estimated necessary. If there is doubt, a clean pen may be filled full the first time, but after that, the ink level should be kept as low as possible for cleanest lines and shortest drying time.

After using the plastic ink bottle, wipe the spout and replace it tightly in the sealing hole in the bottle cap.

STARTING A STUBBORN BOX PEN

If trouble is encountered in getting a box pen to ink, proceed as follows:

1. Remove the pen from the pen-arm. To do this, hold the pen-arm firmly and turn the pen in a counterclockwise direction permitting the clip on the back of the pen to be slipped off the pen-arm. Carefully withdraw the pen from the hole in the pen-arm.
2. Fill the pen nearly full of ink.
3. Grasp the pen reservoir with the thumb on top and forefinger beneath, and squeeze. Ink should start to ooze from the pen tip.

MAINTENANCE OF PEN

If a pen becomes dirty or begins to skip, clean it as described below. Detergent cleaners may be used, but every trace should be removed or severe feathering may result. Use only recorder ink. If long service wears a pen so that the line is too wide, replace the pen.

TO CLEAN A CLOGGED BOX PEN

1. Remove the box pen from its pen-arm. To do this, hold the pen-arm firmly and turn the pen in a counterclockwise direction. This permits the clip on the back of the pen to be slipped off the pen-arm. Carefully withdraw the pen from the hole in the pen arm.
2. Run a wire not larger than 0.005" diameter (B&S Gauge #36 or higher) or a Cleaning Wire, Part P-26488, through the tip to push out the dried ink.
3. Flush out by filling through the tip with the plastic ink bottle. Force through a surplus of ink into a tissue or paper towel to make sure the tip is clean.
4. Replace the pen.

TO REFILL THE PLASTIC INK BOTTLE

1. Pull out the spout and remove the screw cap as shown in Fig. 2.
2. Force the plug sideways, up and out. Don't try to pull it straight.
3. Fill to the line. Replace plug, cap, and spout.

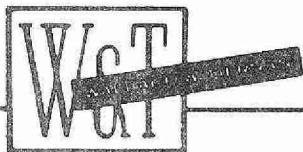


FIG. 15-3

INSTRUCTIONS FOR BOX PEN
W & T RECORDERS

NOTES

NOTES

SUBJECT:

CHLORINATION EQUIPMENT

TOPIC: 16

TROUBLE-SHOOTING

OBJECTIVES:

Trainee will be able to describe and/or demonstrate trouble-shooting chlorinators with a manometer and vacuum gage by determining the following:

- (a) Chlorinator symptoms
- (b) What is probably wrong
- (c) What to measure
- (d) How to measure
- (e) Typical numerical values for proper operation
- (f) Auxiliary checks
- (g) How to remedy symptoms.

INTRODUCTION

Maintaining equipment in operating condition is an important part of any process. Recognizing symptoms when something goes wrong, knowing what to measure and how to measure it will help the operator to keep equipment shut-down periods to a minimum. If he also knows the typical numerical values for proper operation, what auxiliary checks to perform, and how to remedy the symptoms, he may be able to do the repair himself or guide a maintenance man to the exact problem.

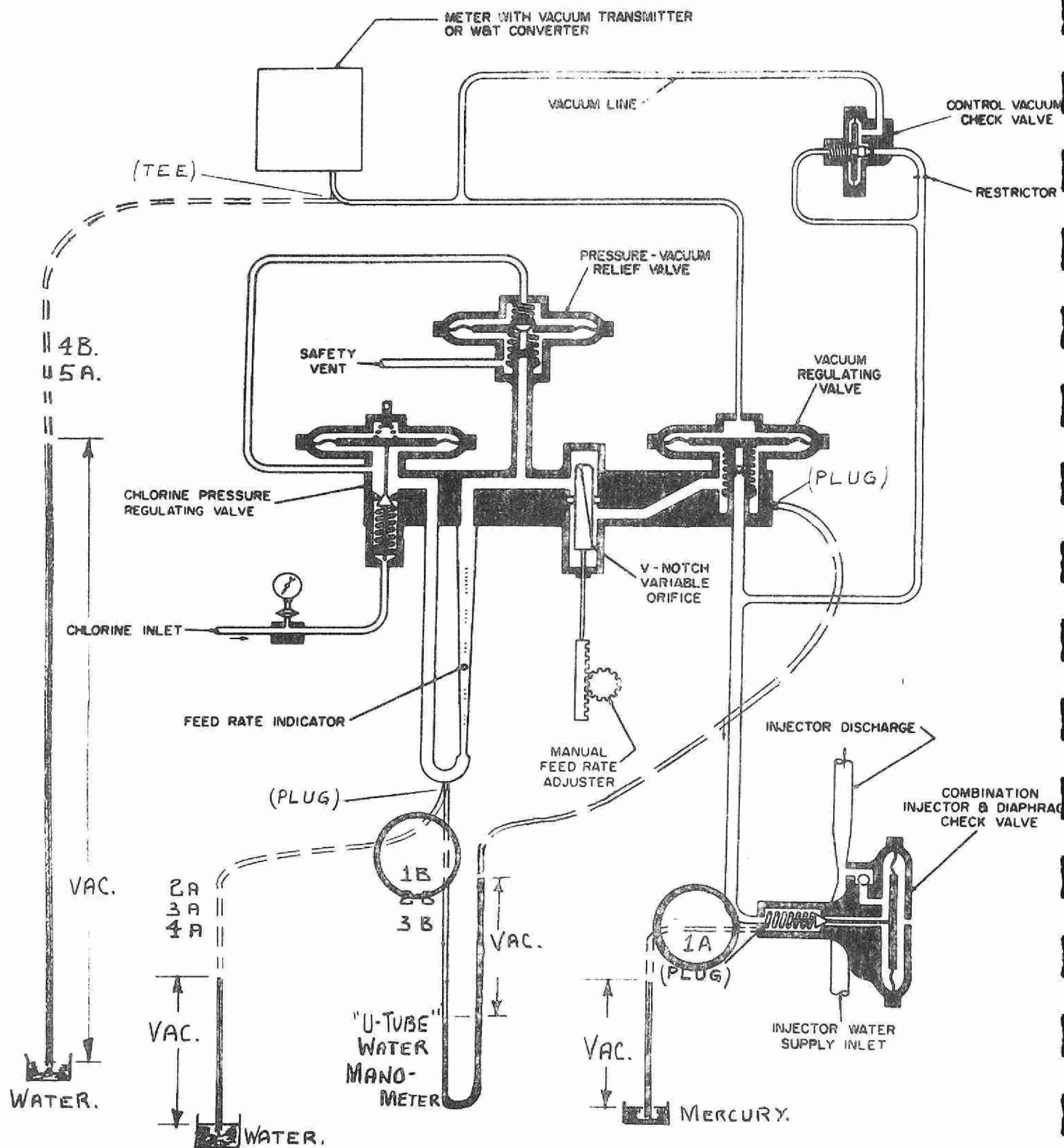
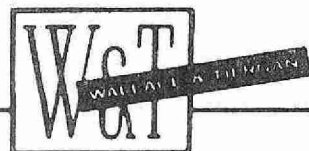


FIG. 16-1

TROUBLE-SHOOTING CHLORINATORS WITH
A MANOMETER AND VACUUM GAUGE



"TROUBLE-SHOOTING" CHLORINATORS WITH A MANOMETER & VACUUM GAGE

- Basic Idea:
1. Measure the vacuum over the full range of gas flow.
(low feed, half feed, full feed)
 2. Compare what you measure with figures given on the schematic flow diagram for your chlorinator or on signal data sheets. If the figures are right leave that component alone and check the next element.
 3. Make auxiliary checks (if necessary) to pinpoint the problem.
 4. Correct the problem.

Examples:

*NOTE: Chlorinator has plugs at most of these vacuum check points.
Fittings must be supplied to make connections to manometer.*

Chlorinator Symptoms	What is Probably Wrong	What to Measure	How to Measure	Typical Numerical Values for Proper Operation	Auxiliary Checks	How to Remedy Symptoms
Manual Chlorinator will not come up to full feed. Gas pressure adequate.	Insufficient Injector vacuum	Injector vacuum.	Observe gage on machine if it has one. If there is no built-in gage, connect a vacuum gage or a mercury manometer at gas inlet to injector. (see 1A, Fig. 16-1)	With gas flowing, 5" mercury minimum for manual control machines. (10" mercury minimum for variable vacuum control machines) With gas shut off you should see 25" to 28½" mercury static vacuum	Measure operating water pressure just upstream of injector and back pressure just downstream of injector. Compare with injector data. Check piping for smooth flow immediately downstream of injector tailway. (No elbows, tees, reducers, etc.) Check for air leaks thru diaphragm of diaphragm-type injector check valves.	Clean injector throat and tailway. Clean or replace solution discharge tubing. Provide adequate operating water pressure. Note: A larger throat and tailway may only compound the problem as the greater flow creates more back pressure.
		V-Notch differential.	Connect a U-tube water manometer upstream and downstream of V-Notch chamber. (see 1B, Fig. 16-1)	11½" to 17" water	Where injector vacuum is marginal or hydraulics are borderline, V-Notch differential is a more sensitive indicator of adequate operating vacuum than the injector vacuum gage. A "bobbing" rotameter float indicates marginal vacuum	

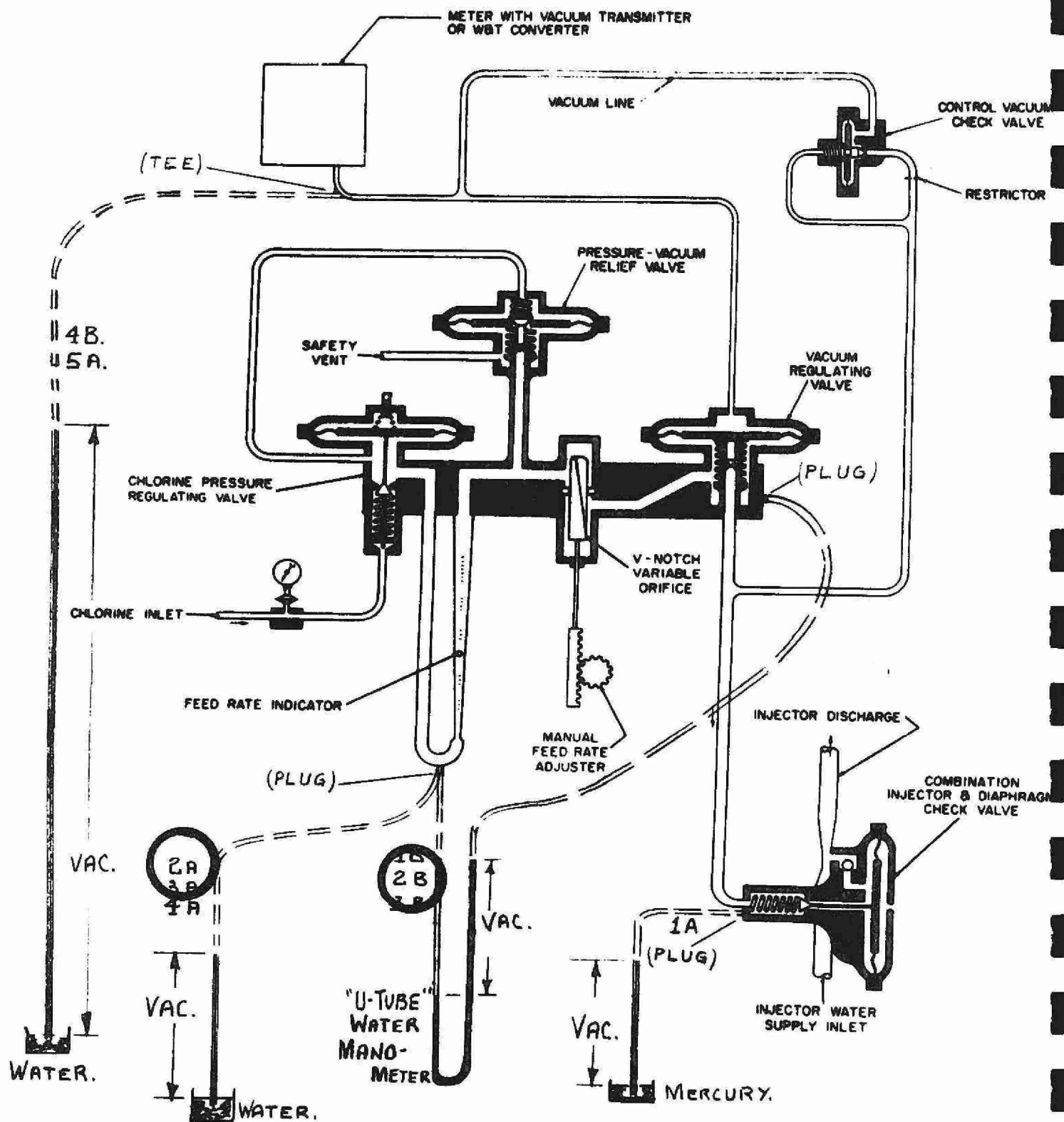
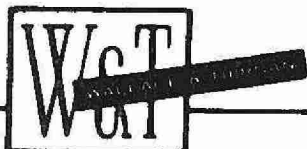


FIG. 16-1
TROUBLE-SHOOTING CHLORINATORS WITH
A MANOMETER AND VACUUM GAUGE



Chlorinator Symptoms	What is Probably Wrong	What to Measure	How to Measure	Typical Numerical Values for Proper Operation	Auxiliary Checks	How to Remedy Symptoms
Manual Chlorinator feeds OK at high rates but will not control at lower rates.	CPRV not throttling sufficiently. (Held open by a particle of rust, ferric chloride, etc.)	CPRV vacuum.	Connect a single leg water manometer at pipe plug opening in the CPRV. (see 2A, Fig. 16-1)	23" to 32" water for 400# machines. 11" to 17" water for 2000# and 8000# machines.	Note especially if vacuum falls at lower feeds. If it does either air or chlorine must be causing it. To find out which, turn off gas at cylinder. If rotameter float drops it was excess gas coming in. If turning off gas does not cause float to drop, air must be leaking in. Then close off vent opening. If float drops air was leaking through the diaphragm. If closing the vent has no effect then air is leaking past a gasket.	Clean CPRV cartridge. Check CPRV diaphragm for "pin hole" leaks. Check CPRV gaskets. On "2-Valve" machines, check pressure relief stem, seat and spring condition. Clean or replace parts as necessary.
	-OR- Possibly a bad diaphragm in the differential valve is causing bypassing of the V-notch control valve.	Differential valve Regulation.	Connect a U-tube water manometer across differential valve. (see 2B, Fig. 16-1)	11½" to 17" water difference.	Pressurize top of differential valve with air and check for leaks in water.	Replace diaphragm on 2000# or 8000# units. Replace valve capsule on lower capacity machines.

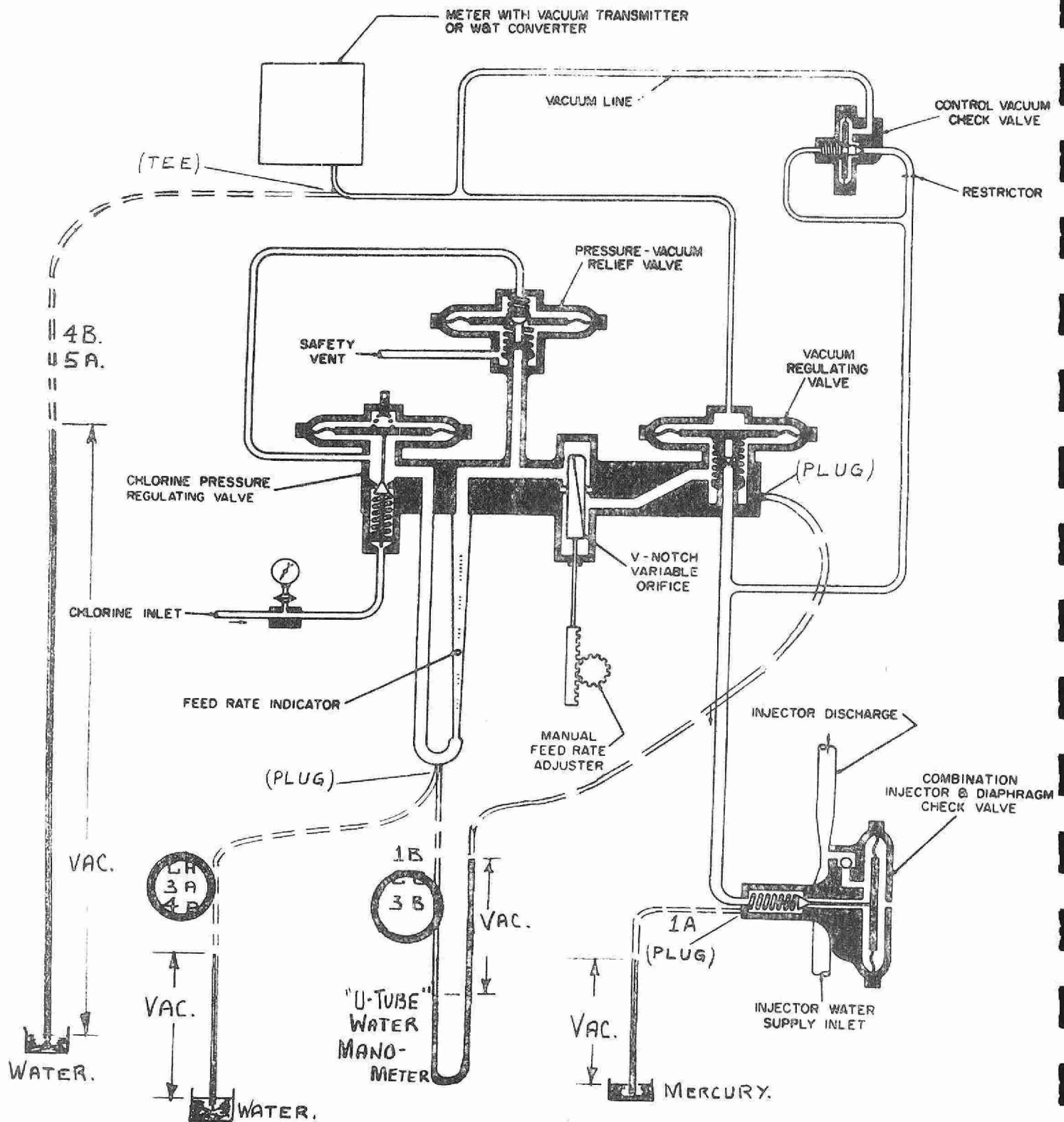
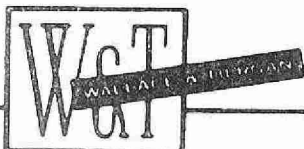


FIG. 16-1

TROUBLE-SHOOTING CHLORINATORS WITH
A MANOMETER AND VACUUM GAUGE



Chlorinator Symptoms	What is Probably Wrong	What to Measure	How to Measure	Typical Numerical Values for Proper Operation	Auxiliary Checks	How to Remedy Symptoms
Manual Chlorinator controls OK at low feeds but is erratic when full feed is attempted. Injector vacuum OK.	Not enough chlorine entering to satisfy demand. Dirty CPRV cartridge or partially clogged gas line.	CPRV vacuum.	Connect a single leg water manometer at pipe plug opening in the CPRV. (see 3A, Fig. 16-1)	23" to 32" water for 400# machines. 11" to 17" water for 2000# and 8000# machines. If gas line or cartridge is partially clogged CPRV vacuum will increase to vacuum relief level. (Caution-start at low feed rates and gradually increase feed to prevent "blowing" manometer.)	Check gas supply pressure. See if air is entering vacuum relief port at high feeds. Check vacuum relief level with a single leg manometer	Clean CPRV cartridge. Clean high pressure gas line. Supply adequate chlorine gas pressure (20 psig is the minimum full feed performance - except on low rate apparatus).
Chlorinator does not feed anything. Gas pressure is adequate. Injector vacuum is OK.	Tube connection from upstream of V-Notch to top of differential valve is disconnected or leaking.	CPRV vacuum	Connect a single leg water manometer at pipe plug opening in the CPRV. (see 3B, Fig. 16-1)	23" to 32" water for 400# machines. 11" to 17" water for 2000# and 8000# machines.	On automatic machines make sure V-Notch plug is not remaining in closed position	Re-connect tube line. Replace tube if cracked, kinked or defective at ends. Tighten tube nuts

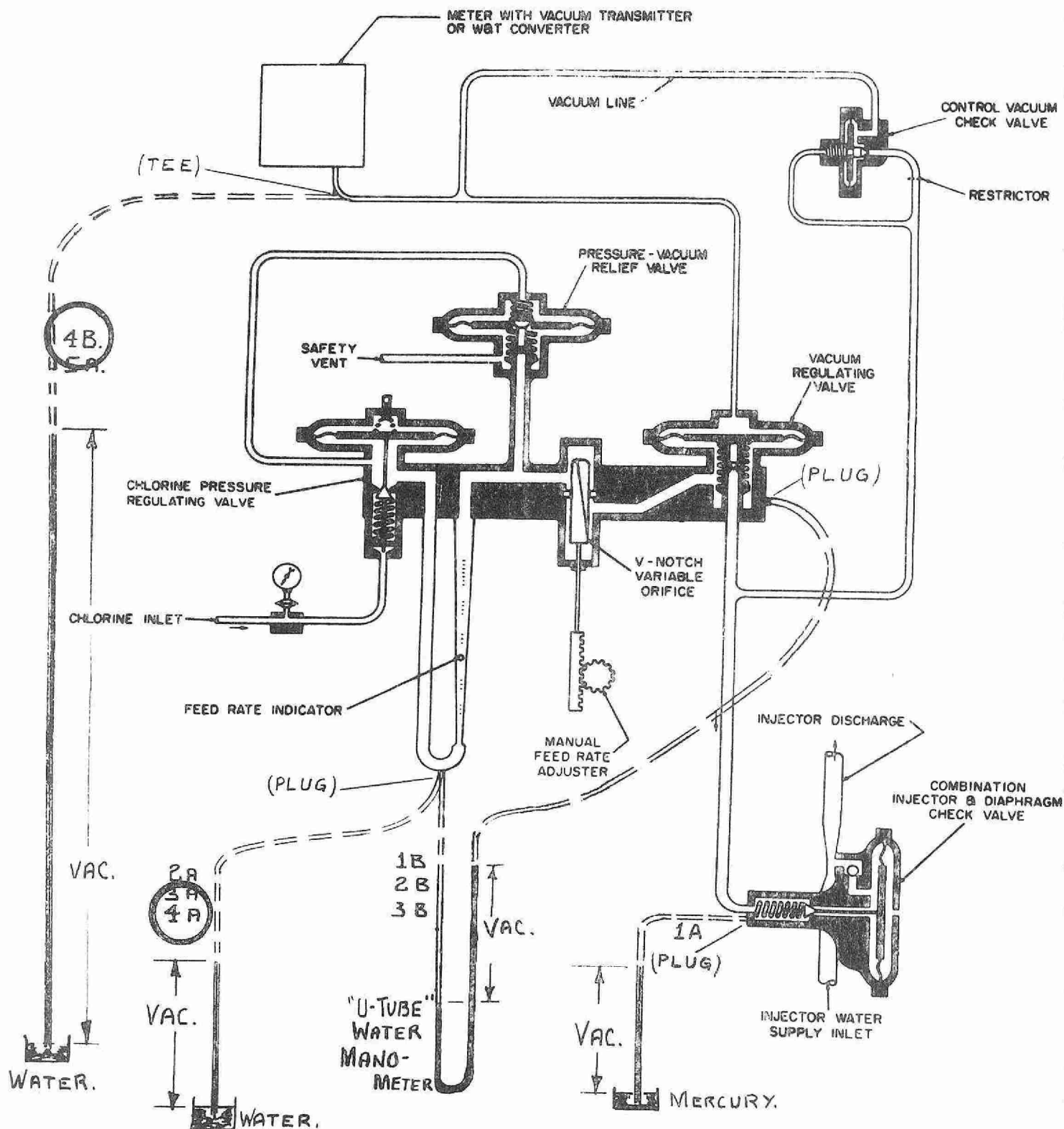
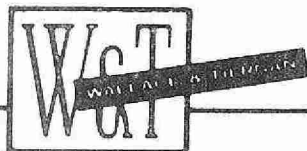


FIG. 16-1

TROUBLE-SHOOTING CHLORINATORS WITH
A MANOMETER AND VACUUM GAUGE



Chlorinator Symptoms	What is Probably Wrong	What to Measure	How to Measure	Typical Numerical Values for Proper Operation	Auxiliary Checks	How to Remedy Symptoms
A variable vacuum control chlorinator, formerly working normally now won't go below, say, 30% feed. Signal levels OK.	CPRV not throttling sufficiently for low feeds. (Held open by a particle of contaminant on seat or stem.)	CPRV vacuum	Connect a single leg water manometer at pipe plug opening in CPRV. (see 4A, Fig. 16-1)	Approximately 8" of water less than for manual machines of the same type.		Clean CPRV cartridge. Re-adjust bias spring at about 20% feed after reassembly.
A variable vacuum control chlorinator reaches full feed OK but won't go below, say, 40 to 50% feed. CPRV is OK.	Signal vacuum too high because of air leak by-passing restrictor through diaphragm of control vacuum check valve.	Signal vacuum. Remember half feed occurs at only one quarter signal. Chlorinator merely feeds what the signal "tells" it to feed. If signal vacuum does not go down, chlorinator feed won't go down.	Tee in a single leg water manometer at the signal connection at top rear of chlorinator cabinet. (see 4B, Fig. 16-1)	88" water for full feed. 53" for 3/4 feed 28" water for half feed. 14" for 1/4 feed 9.6" water for 1/7th (14.3%) feed. Note range limit of 7:1	Air-tight quality of control vacuum check valve diaphragm. Check gasket and stem in diaphragm. Check felt filter disc for restriction due to dirt or moisture accumulation. Check converter flapper and nozzle for freedom from dirt or restriction.	Replace diaphragm, gasket or stem as tests indicate source of leak. Clean and dry or replace filter disc. Clean converter nozzle.

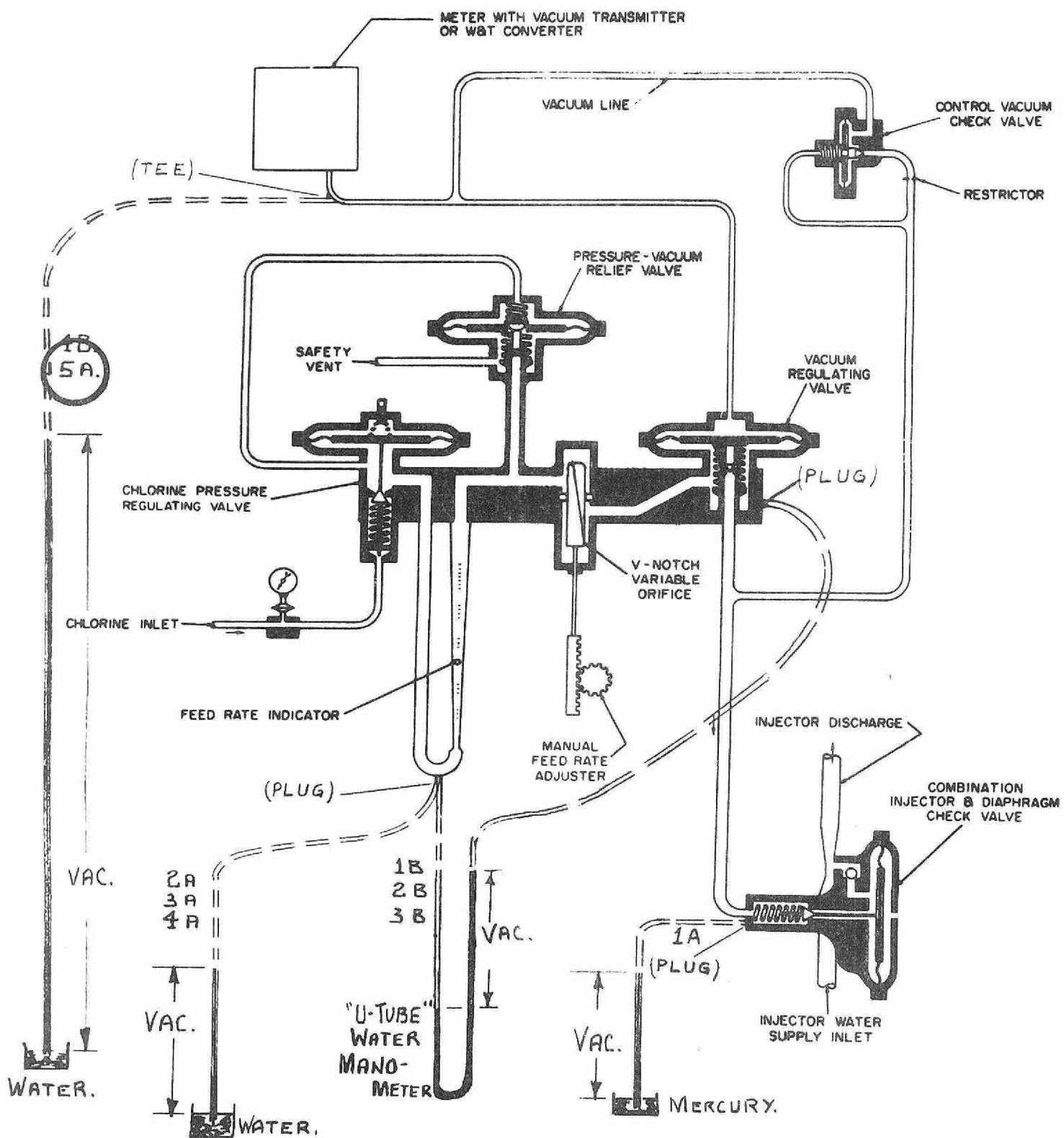
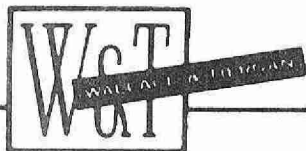


FIG. 16-1

TROUBLE-SHOOTING CHLORINATORS WITH
A MANOMETER AND VACUUM GAUGE



Chlorinator Symptoms	What is Probably Wrong	What to Measure	How to Measure	Typical Numerical Values for Proper Operation	Auxiliary Checks	How to Remedy Symptoms
A variable vacuum control chlorinator refuses to go to full feed. Gas pressure adequate. CPRV is clean. Injector vacuum is OK.	Signal vacuum too low because of plugged restrictor in control vacuum check valve - OR - air leaking into signal line.	Signal vacuum. Remember signal must become over 3 times as high to get from half feed to full feed.	Tee in a single leg water manometer at the signal connection at top rear of chlorinator cabinet. (see 5A, Fig. 16-1)	28" water for half feed. 59.2" water for 80% feed. 88" water for full feed. Note that signal range need not be exactly 8 to 88" water. Low end should be in the area of 7 to 9" water. Upper end should be in the area of 70 to 95" water. Work out numbers for your installation as explained on sheets entitled "The Arithmetic of Variable Vacuum Control".	Check connecting line from signal converter to chlorinator. Pressurize with air and use soap solution or submerge in water and look for bubbles. As an alternate, trap air under pressure and observe a T'ed in gage. Fall of pressure indicates a leak. Check joints, fittings, tube ends, retainer nuts, etc.	Remove and clean restrictor. Use solvent and a wire smaller than its .009 bore. Use teflon tape on threaded joint. Correct any vacuum leaks in signal lines. System must be "dead tight" due to very limited capacity of restrictor orifice.

NOTES

SUBJECT:

TOPIC: 17

CHLORINATION EQUIPMENT

CHLORINE RESIDUAL ANALYZER
AND CONTROLLER

OBJECTIVES:

Trainee will be able to:

1. describe the basic principles of the chlorine residual analyzer and controller
2. recognize the most common maintenance problems of residual analyzer recorders and recorder controllers.

1. RESIDUAL ANALYZER RECORDER

Purpose

The purpose of the residual recorder is to continuously indicate and record the residual of chlorine in a plant discharge and/or at any point within the plant.

Principle of Operation

A controlled sample of water is fed into a cell in which there are two electrodes of different metals (e.g. bronze and platinum).

A buffer solution is added to maintain the pH within a pre-determined range.

The presence of chlorine in the water sample acts as an electrolyte between the two dissimilar metals and causes a small D.C. electrical current which is proportional to the amount of chlorine in the sample.

This is basically a *titrator* working on a continuous basis.

The small electrical current generated by the cell assembly (analyzer) is fed into an amplifier system and changed to a control voltage to activate a servo-type motor.

The servo motor will then drive the gear train to position the pen on the chart and the feed-back potentiometer in the balancing circuit until the control voltage and balancing voltage are equal. At this point, the motor will stop.

An increase or decrease in the residual of the water entering the cell will cause a corresponding change in the position of the pen on the chart.

The operation of this unit must be checked daily or weekly (as experience will dictate). It can only be checked accurately with the use of an amperometric titrator (see Topic 20).

The residual recorder can be used to record *either* free or total chlorine residual.

For free chlorine residual recording, a pH 4 buffer solution is used, and for total chlorine residual, a pH 7 buffer plus iodine tablets are used. In some cases where reading total chlorine residual, if the pH of the water is within certain limits, a buffer solution is not required.

Chlorine Residual Alarms

Can be activated by the use of electrical contacts adjustable to any point within the ~~range~~ of movement of the pen. These contacts are designed to activate a relay to pull in an alarm system, and will not handle the amperage required to operate the alarms.

2. RESIDUAL RECORDER-CONTROLLER

Purpose

The purpose of the residual recorder-controller is to continuously indicate and record the residual of water, and to increase or decrease the chlorinator accordingly.

Principle of Operation

This equipment consists of exactly the same equipment as described under "Residual Recorder" with the addition of

electrical contacts and "set point" control, plus relays, to control the increase or decrease of the chlorinator feed.

This unit allows a "loop system" for automatic control in a plant (see Fig. 4-4).

3. MAINTENANCE PROBLEMS

General

Since the time involved in the transfer of water and sample through the control loop system is critical, it is important to adhere very closely to the manufacturer's specifications for setting up and regulating the equipment which will give the best operating conditions for a particular plant.

Maintenance

The cell assembly should be cleaned as required by the suggested maintenance program and/or as dictated by operating conditions, and the method, materials, etc., should follow the manufacturer's specifications.

Leads from the cell (analyzer) to the recorder unit should be inspected regularly for corrosion. This is particularly important for older models of equipment.

Electrical contacts should be cleaned whenever they appear dirty or perform erratically.

The use of a voltmeter with a low range D.C. millivolt scale can indicate whether or not:

- (a) the cell and electrode assembly is producing an electrical signal,
- (b) the amplifier is converting this signal to the motor requirements.

The use of a voltmeter will also verify if the contacts are energizing the required alarm or control circuits. Examination of the manufacturer's electrical drawings will indicate

where to check this, and what readings should be expected.

If for any reason gears or mechanical linkages are taken apart, they should be marked with check lines to facilitate re-assembling into their original position(s).

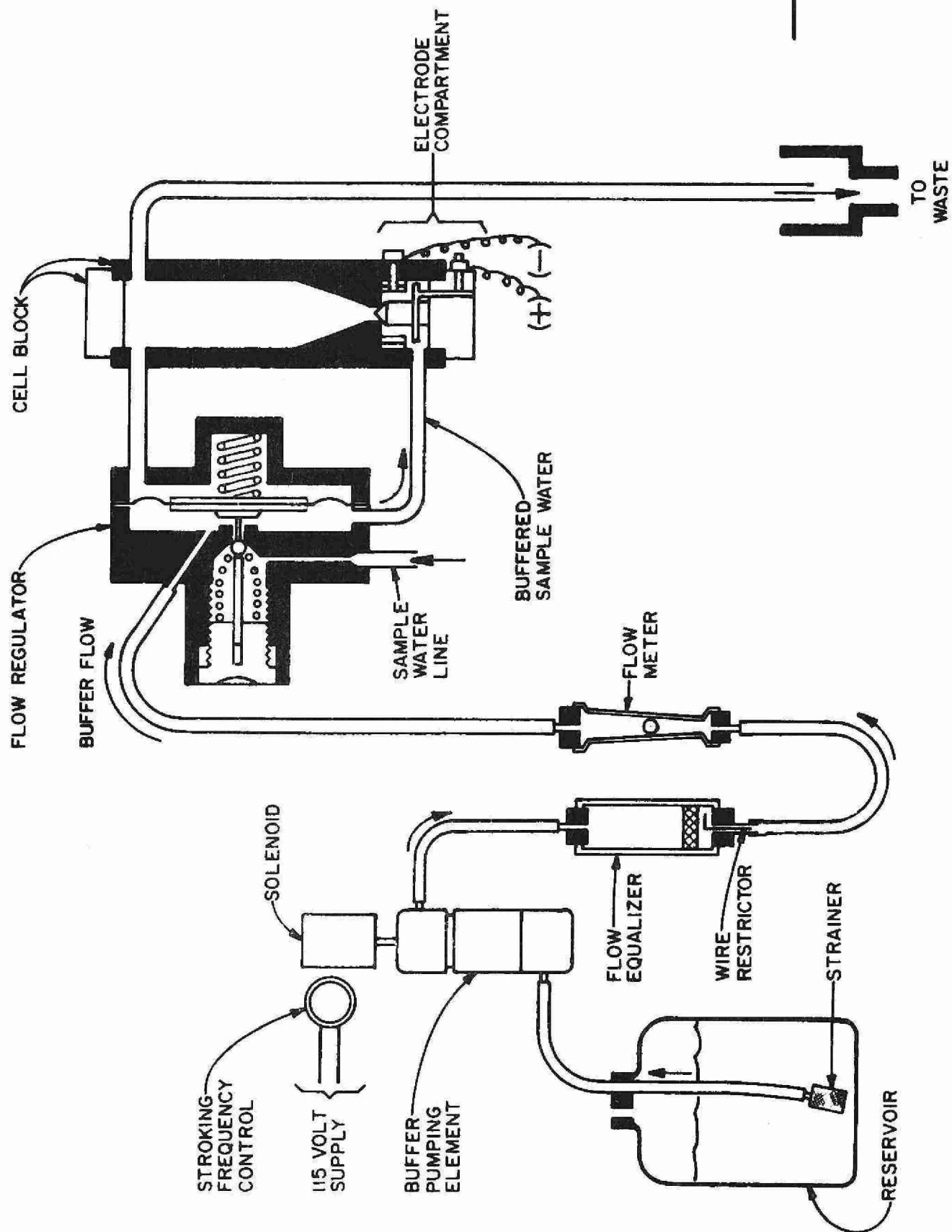


FIG. 17-1 - RESIDUAL CHLORINE SAMPLING CELL FOR WATER

RESIDUAL CHLORINE ANALYZER

FLOW DIAGRAM

For Wastewater

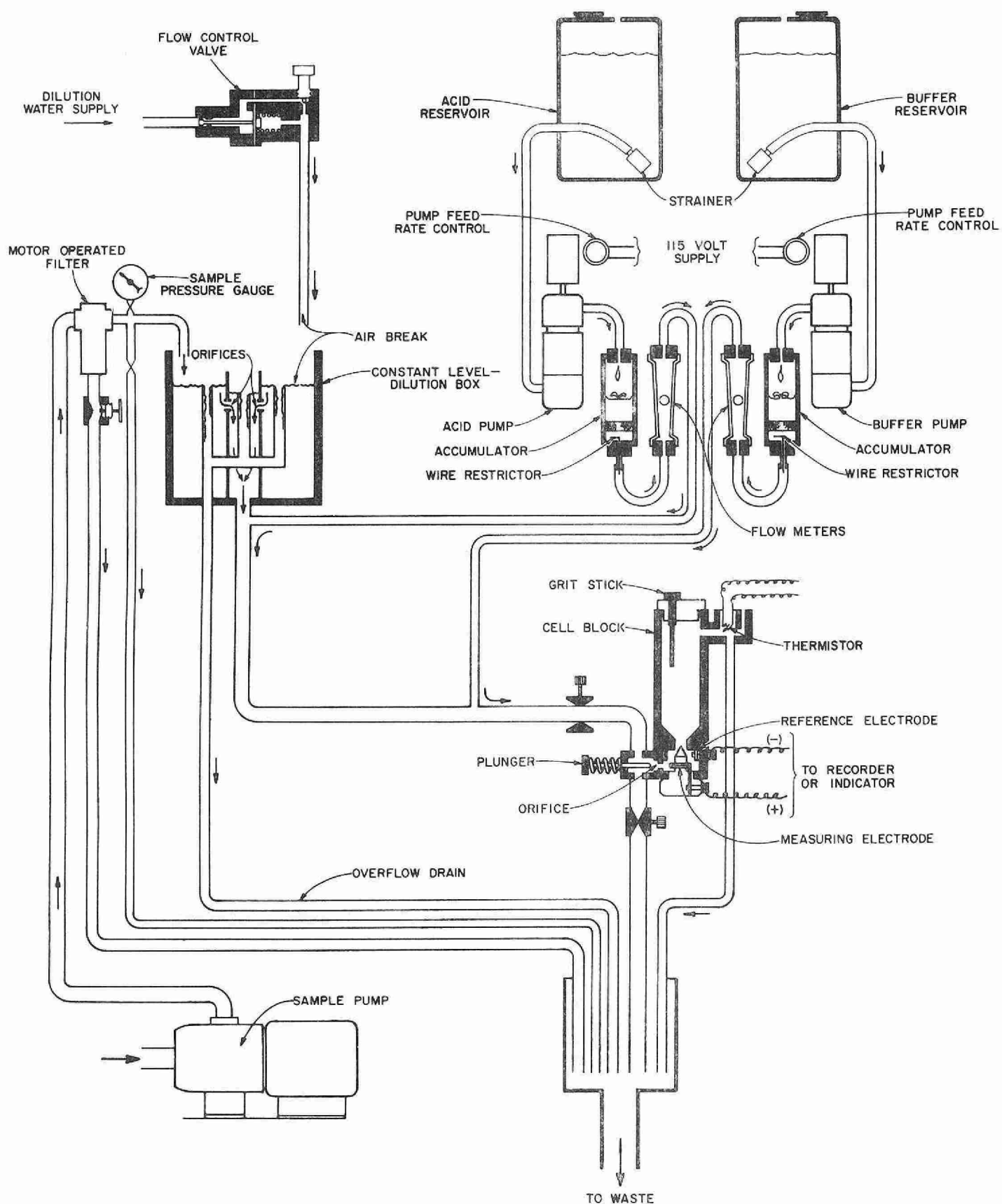
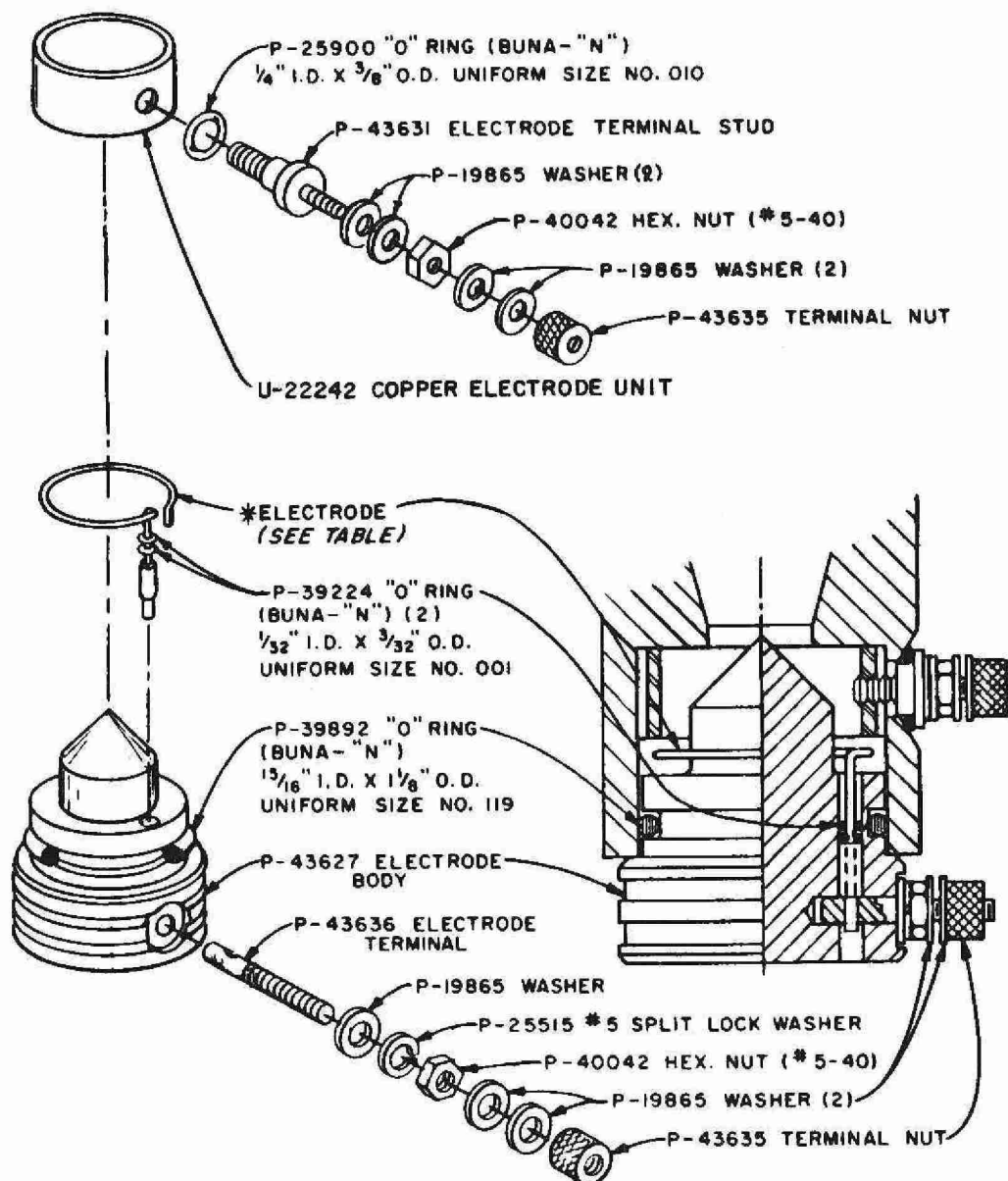


FIG. 17-2 - RESIDUAL CHLORINE SAMPLING
CELL FOR WASTEWATER

DETAIL OF MEASURING CELL

PARTS

Used In U-21279 Residual Chlorine Sampling Cell



UNIT NO.	TURNS	USED WITH	
		A-780 INDICATOR	A-767 RECORDER OR INDICATOR
U-20734	ONE (SHOWN)	ALL EXCEPT 0-1 PPM	ALL
U-21276	TWO	0-1 PPM	NONE

* NOT PART OF CELL

PENWALT
WALLACE & TIERNAN
DIVISION

FIG. 17-3 - ELECTRODES

TYPE U-18860 DRIVE UNIT

PARTS

Used In W&T Recorders

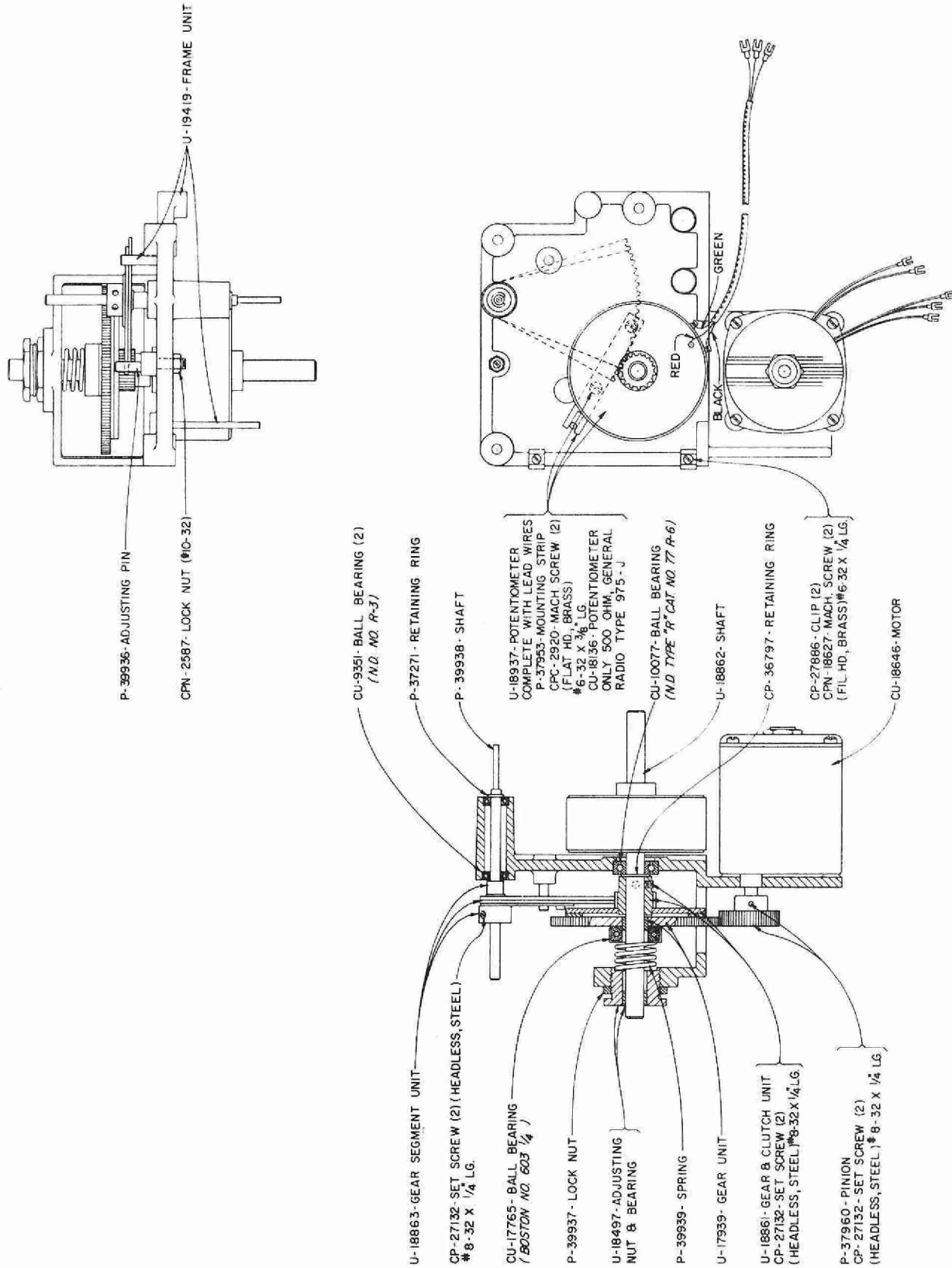
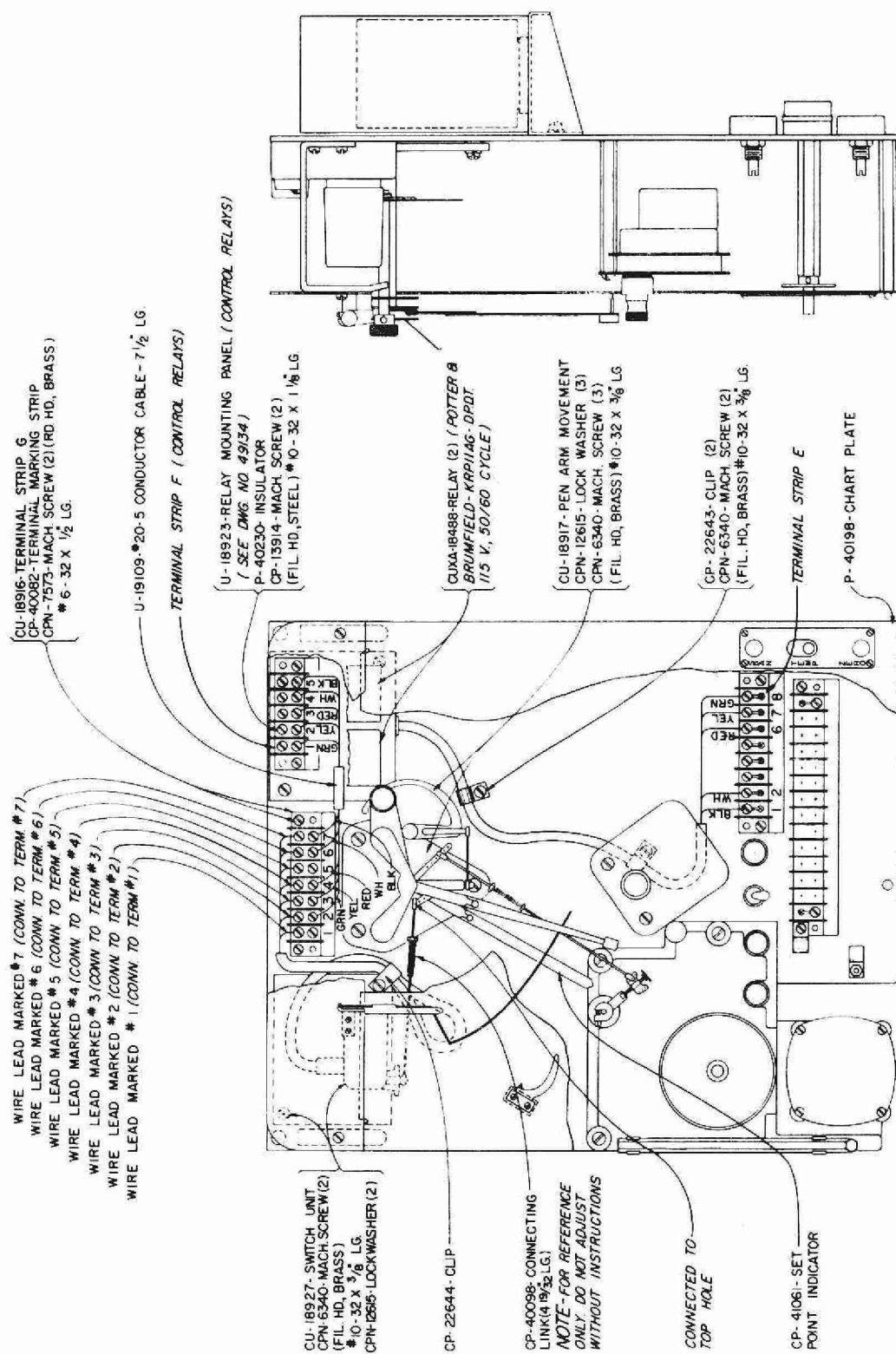


FIG. 17-4 - PEN DRIVE UNIT

Series A-767 Chlorine Residual Recorder-Controller



NOTES-- FOR PARTS ILLUSTRATED BUT NOT IDENTIFIED SEE DWG NO. 49121

FOR INTERNAL WIRING & CABLING SEE--

DWG. NO. 49120 (A-767021)

DWG. NO. 49558 (A-767022, 023)

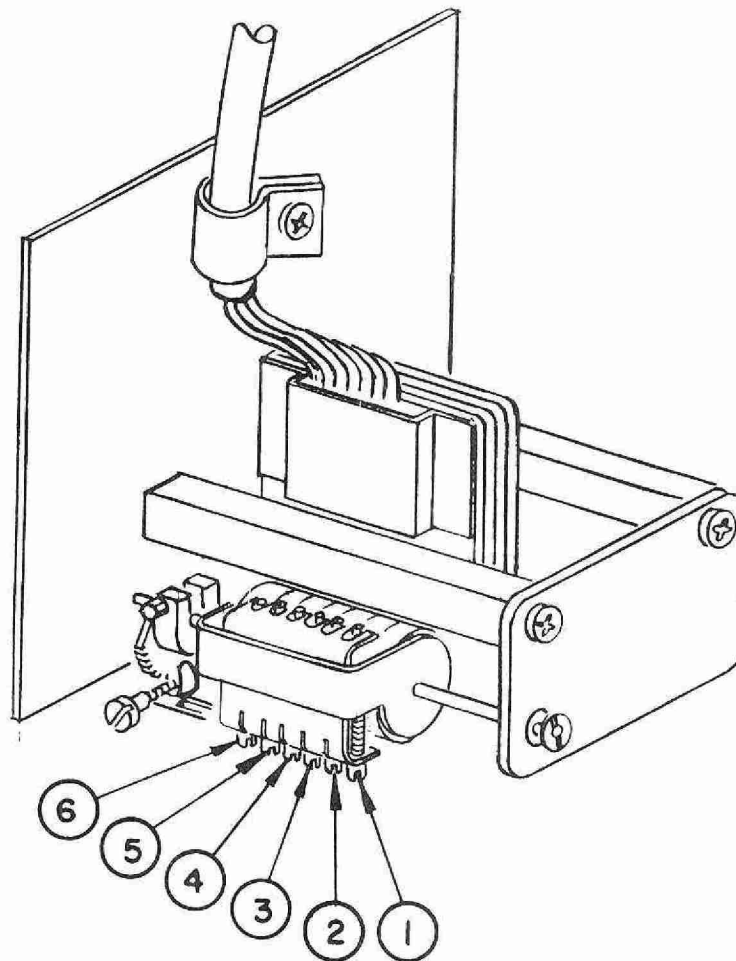
DWG. NO. 49888 (A-767024)

FOR CASE DETAILS SEE

DWG. NO. 49116 (A-767021 & 022)

DWG. NO. 49608 (A-767023, 024)

FIG. 17-5 - RECORDER FACE



- 2 - ADJUSTMENT POINT FOR LOW READING LOCK UP CONTACT SETTING
- 3 - ADJUSTMENT POINT FOR LOW READING CONTROL CONTACT SETTING
- 4 - ADJUSTMENT POINT FOR HIGH READING LOCK UP CONTACT SETTING
- 6 - ADJUSTMENT POINT FOR HIGH READING CONTROL CONTACT SETTING

- 1 - ADJUSTMENT POINT FOR HIGH READING ALARM CONTACT SETTING
- 5 - ADJUSTMENT POINT FOR LOW READING ALARM CONTACT SETTING

*NOTE--- CONTACTS 1 AND 5 USED ONLY IF ALARMS ARE FURNISHED.
CLOCKWISE ROTATION OF ADJUSTING SCREW MOVES OPERATING POINT
OF THAT CONTACT DOWN SCALE. SEE INSTRUCTION TEXT FOR
DISCUSSION OF ADJUSTMENT.*

*DO NOT ATTEMPT TO ADJUST SETTINGS WITH POWER TO RECORDER ON.
REFER TO TEXT FOR INSTRUCTIONS*

FIG. 17-6 - SWITCH UNIT -
ALARM AND CONTROL POINTS

NOTES

NOTES

SUBJECT:

TOPIC: 18

CHLORINATION LABORATORY

DPD METHOD

OBJECTIVES:

For the DPD Method, trainee will be able to:

1. determine the reagents required for the Nessleriser or Comparator.
2. determine the ranges covered by the Nessleriser and Comparator discs.
3. demonstrate the procedures to follow using the Nessleriser and Comparator.

GENERAL

In a recent investigation by the Water Research Association this method was judged the BEST COLORIMETRIC METHOD for chlorine and chloramines in water. The procedure has been greatly simplified by the use of tablets. Being free from interference from bromides the method is suitable for use in sea-water baths.

(For details of a special portable set for use with this test apply to THE TINTOMETER LTD., Salisbury, England).

PRINCIPLE OF THE METHOD

Researches in chlorine chemistry have resulted in the development of a very simple procedure for the determination of residual chlorine compounds in water. Depending upon the information required, it may be adapted to give total chlorine residual, or free and combined chlorine residual. Differentiation, which with the new DPD indicator is remarkably clear-cut, into these various forms of chlorine residual is of the greatest importance in the control of modern chlorine processes of water treatment.

A novel feature of the Lovibond Comparator method lies in the use of compressed tablets which, besides being far more convenient in use, permit the reagents being combined together to give a procedure of exceptional simplicity.

REAGENTS REQUIRED

Comparator

DPD tablets

- (a) No. 4 (or Nos. 1 & 3) for total chlorine residual
- (b) Nos. 1 & 3 for free and combined chlorine residual

Nessleriser

DPD tablets

- (a) Nos. 1 & 3 together for total chlorine residual
- (b) No. 1 for free and No. 3 for combined chlorine residual

THE STANDARD LOVIBOND DISCS

Comparator

3/40A disc covers the range 0.1 to 1.0 parts per million chlorine.

3/40B disc covers the range 0.2 to 4.0 parts per million chlorine.

These discs require 13.5 mm. cells or test tubes. A dulling screen, which is common to both discs, must be used.

Nessleriser

NDP covers the range 0.05 to 0.5 p.p.m. This disc must be used with a dulling screen and 50 ml. tubes.

PROCEDURE

Comparator

1. Total Chlorine Residual

- (a) place a 13.5 mm cell or test tube containing sample only in the left-hand compartment, behind the colour standards of the disc
- (b) rinse a similar cell with the sample, and
- (c) leave only enough sample liquid to cover the tablet when added.

NOTE: *There are different tablet manufacturers - check their recommended procedures.*

- (d) into this prepared tube drop one No. 1 and one No. 3 tablet (or one No. 4 tablet, which is No. 1 and No. 3 combined)
- (e) allow tablets (or tablet) to disintegrate until effervescence ceases
- (f) add water sample up to the 10 ml mark, and
- (g) *mix rapidly* to dissolve the remains of the tablet
- (h) place the cell in the right-hand compartment of the Comparator
- (i) *after 2 minutes*, match the cells by holding the Comparator facing a good source of diffused north daylight and *revolve this disc until the correct standard is found*

NEVER LOOK INTO THE SUN
- (j) the figure shown in the indicator window represents parts per million (ppm) of *total chlorine residual* present in the sample.

2. Differential Estimation of Free and Combined Chlorine Residual

- (a) prepare tubes as above for total chlorine residual, one "blank" tube and one with just a few drops of sample

NOTE: *If monochloramine content is high, differentiation is improved by using distilled water instead of the sample for disintegrating the tablet.*

- (b) to the tube with sample, add one No. 1 tablet only

- (c) after disintegration, add water up to 10 ml mark, and
- (d) mix as before and match at once
This gives free chlorine residual
- (e) then add one No. 3 tablet, mix and stand for 2 minutes
The colour then read off represents total chlorine residual
- (f) subtract free chlorine residual from total chlorine residual. Then,
Total Chlorine Residual - Free Chlorine Residual = Combined Chlorine Residual Value.

Nessleriser

1. Follow exactly the same procedure for the Comparator, with the following exceptions:
 - (a) use 50 ml instead of 10 ml
 - (b) use special Nessleriser DPD tablets
 - (c) there is NO No. 4 Nessleriser tablet - use No. 1 and No. 3 instead

NOTE: *It must be emphasized that the readings obtained by means of the B.D.H. Lovibond Nessleriser and disc are only accurate provided that Nessleriser glasses are used which conform to the specification employed when the discs were calibrated, namely that the 50 ml. calibration mark shall fall at a height of 113 ± 3 mm.; measured internally.*

FALSE COLOUR DUE TO INTERFERENCES

1. Dissolved oxygen in water can produce a faint colour with the reagent if allowed to stand; however, there is no interference within the period of the test.

2. The only interfering substance likely to be present in water is oxidized manganese. Its effect can be allowed for by developing the manganese colour in a "blank" as follows:-

To 10 ml of sample in a separate test tube add one DPD tablet No. 2 and one drop of 0.5% sodium arsenite (NaAsO_2) solution. Mix to dissolve. Rinse Comparator cell or test tube as before and add 1 DPD tablet No. 1. Allow to effervesce for its duration and then add the 10 ml of arsenite-treated sample. Mix to dissolve remains of tablet and then place in left-hand side of Comparator. In this way the colour due to manganese will have been developed equally in both fields and thus cancels out.

3. *All glassware used must be very thoroughly rinsed after making a test, since only a trace of potassium iodide will cause chloramine colour to develop. For the same reason handling the tablets, particularly DPD No. 1, should be avoided. By shaking one tablet into the bottle top it is a simple matter to use the top for conveying the tablet to the Comparator cell.*
4. The quantity of indicator used in the tablets has been chosen to suit the range of chlorine concentrations covered by the discs, that is up to 4 parts per million. Samples containing higher concentrations must be diluted. Concentrations of chlorine above 8 p.p.m. will entirely bleach the colour, and give an apparently zero reading, but at this concentration the smell of chlorine would be very apparent. If there is any doubt about the need for dilution a simple check is to repeat the procedure using two DPD No. 1 tablets instead of one. A very decided increase in colour would indicate dilution to be necessary, in which case the requisite amount of distilled water is added first to the reagent by the measured amount of sample.



Figure 18-1 - B.D.H. Lovibond Nessleriser

NOTES

NOTES

SUBJECT:

TOPIC: 19

CHLORINATION LABORATORY

ORTHOTOLIDENE TEST

OBJECTIVES:

Trainee will be able to describe and/or demonstrate:

1. the orthotolidene method for total chlorine residual
2. the orthotolidene flash test method for estimating free chlorine.

GENERAL

The orthotolidene test (OT) is used to determine the presence of chlorine residuals in the water.

The water is tested for total chlorine residual 15 minutes or longer after dosing by adding the sample to the OT reagent in a glass tube or glass container. To test for free chlorine residual the OT reagent is added to the sample. A yellow colour in the sample indicates the presence of a chlorine residual. The deeper the yellow the greater the residual. A lemon yellow colour indicates a safe residual for drinking water.

Free chlorine residual can be distinguished from combined residual under given conditions of time and temperature. The colour caused by free chlorine residuals develops instantly at low water temperatures after the OT reagent is added to the sample. Colour caused by the combined residual develops more slowly, and normally takes up to 5 minutes. The speed of colour development of combined residuals is increased with higher water temperatures.

It is possible that in highly alkaline waters (quite rare in Ontario) a blue tinge may result instead of the yellow colour. This may be corrected by adding an excess amount of OT reagent. Since the reagent is acidic, it will neutralize the excess alkalinity in the water sample. It should be noted

that adding an excess amount of OT reagent introduces inaccuracies in the residual reading.

The OT method is an old one dating back to 1914, and is still in use in many plants. However, it does have certain disadvantages. Principally, inaccuracies in determining between free and combined residual and also when the total residual is greater than 1.0 ppm. To add to this iron, manganese and nitrites can cause a false colour. The OT method is slowly being replaced by the DPD and the Amperometric methods both of which will be discussed in this workshop.

PROCEDURE FOR TOTAL CHLORINE RESIDUAL

1. Pour the required amount of OT reagent into the Nessler tube, colorimeter cell or other container

Use 0.5 ml OT reagent in 10 ml cell

0.75 ml OT reagent in 15 ml cell

5.0 ml OT reagent in 100 ml cell

and similar ratios for other volumes

NOTE: OT reagent should not be kept longer than 6 months. It should be stored in amber coloured bottles, kept out of direct sunlight and should not be subjected to high or low temperature. Preferably OT reagent should be maintained at about 68°F. Fresh supplies of OT reagent may be obtained free of charge from the OWRC Laboratories.

2. Add sample to the proper mark or volume.

3. Mix the solution.

4. Temperature

When the temperature of the sample is less than 20°C (68°F), bring it to that temperature quickly after mixing it with orthotolidine. If a Comparator cell is used, place it in hot water until the specified temperature is reached. If a Nessler tube is used, it may be handled in the same manner as the cell, or the contents may be transferred to a flask for heating.

5. Colour Development and Comparison

Colour comparison should be made at the time of maximum colour development. If the potable sample contains predominantly free chlorine, the maximum colour appears almost instantly and begins to fade. Samples containing combined chlorine develop their maximum colour at a rate that is largely dependent on temperature, although the nitrogenous compounds present may influence this rate. Usually at 20°C maximum colour develops in about 3 minutes; at 25°C, in about 2.5 minutes; and at 0°C, in about 6 minutes. About 5 minutes after maximum colour develops, a slight fading begins. Therefore, samples containing combined chlorine should be read within 5 minutes and should, preferably, be allowed to develop colour in the dark.

PROCEDURE FOR FREE CHLORINE RESIDUAL

Introduction

An orthotolidene *flash test* modification for free chlorine residual performed near 1°C (34°F) or freezing point minimizes the effect of chloramines and their reaction with orthotolidene to produce a yellow colour. Temperature is a critical factor. The sample should be near the freezing point to obtain meaningful results. This is in direct contrast to the OT procedure for combined chlorine residual where the temperature of the sample should be around 20°C (68°F).

Although oxidized manganese affects the test results, slow-acting interfering substances, nitrites and oxidized iron, do not have a significant influence.

The flash test has the disadvantage of requiring the reading of colour within 5 seconds.

Procedure

1. Place a sample of water cooled to as close to the freezing point as possible into a Comparator cell or container. This can be accomplished by placing

the cell into a bath of ice cubes or freezer. The dimensions of the container should be such as to ensure immediate and complete mixture of the OT reagent with the sample.

2. Hold the container against a white background and using a medicine dropper *ADD WITH FORCE* the required amount of OT reagent to the sample of water, paying close attention to colour development. The amount of OT reagent depends on the size of the cell - refer to point 1 under Procedure for Total Chlorine Residual.

Read colour within 5 seconds.

NOTE: *This method is suitable for estimating only.*

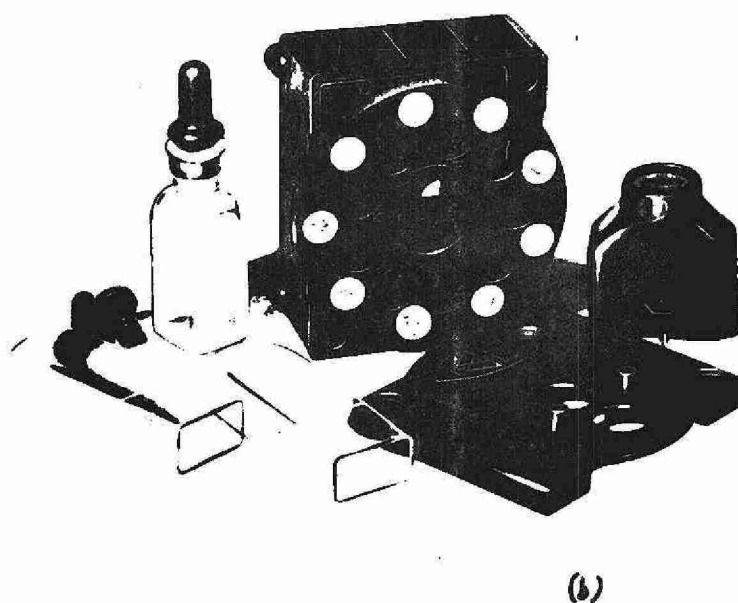
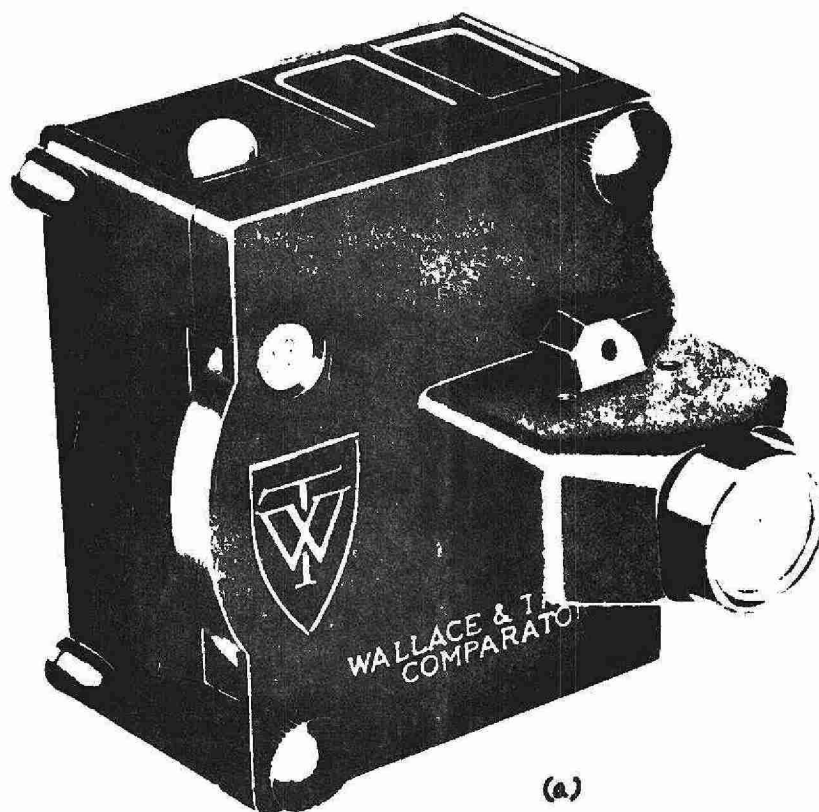


Figure 19-1 (a) and (b) - Wallace & Tiernan Comparator

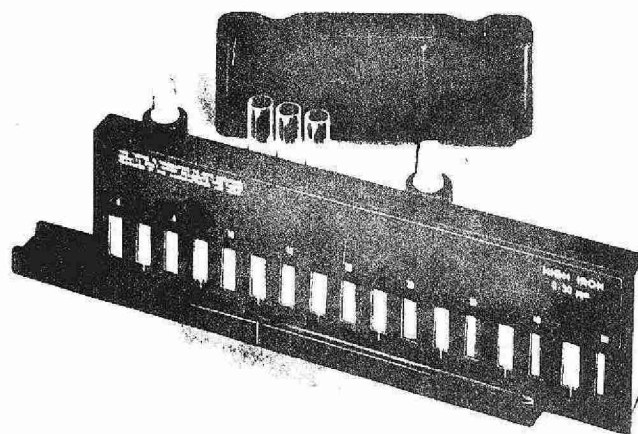


Figure 19-2 - Taylor Chlorine Residual Comparator

NOTES

NOTES

SUBJECT:

CHLORINATION LABORATORY

TOPIC: 20

AMPEROMETRIC TITRATION
METHOD

OBJECTIVES:

Trainee will be able to describe and/or demonstrate the following:

1. principle of titration
2. titration - principle of operation
3. method to determine free chlorine residual
4. method to determine combined chlorine residual
5. method to determine total chlorine residual
6. interpretation of results
7. monochloramine and dichloramine differentiation.

NOTE: TRAINEE WILL NOT BE HELD
RESPONSIBLE FOR THIS TOPIC
DURING THE BASIC GAS
CHLORINATION WORKSHOP.

GENERAL

The most accurate methods of measuring free and combined chlorine residuals is through oxidation-reduction titration procedures. Such methods require the use of internal indicators or electrometric devices employing a suitable electrode system to show when reactions are completed. Amperometric titrators (Figure 20-1) employing rotating platinum electrodes have been developed for such purposes.

Phenylarsine oxide is the reducing agent normally used as the titrating agent. It reacts with free chlorine residuals at pH 6.5 to 7.5 in a quantitative manner.

By conducting a two-stage titration, with the pH adjusted at about 7 and then at about 4, it is possible to

measure separately free chlorine residuals and combined chlorine residuals. Interference from nitrites and oxidized forms of manganese are eliminated by conducting the titrations at pH levels above 3.5.

PRINCIPLE OF TITRATION

Titration is a method used to determine the concentration of a substance in a solution. This is accomplished by adding the smallest amount of a reagent (of known concentration) required to cause a neutralizing effect, in reaction with a known volume of the test solution. A graduated vessel (or pipet) is used to add the reagent to the known volume of test solution until the chemical reaction between the two is completed. The chemical reaction is observed on a microammeter.

TITRATOR: PRINCIPLE OF OPERATION

A direct current potential is impressed across two noble metal electrodes contained in a measuring cell. The measuring cell is immersed in a sample of the solution to be tested. The flow of current between the electrodes is directly proportional to the quantity of halogen (such as chlorine, bromine, or iodine) in the sample. The amount of current is indicated on a microammeter which is connected in series with a measuring circuit.

A reagent (also called a titrant) is added to the water, and reacts chemically with the chlorine present in the solution, thereby neutralizing a portion of the chlorine. As more titrant is added, more chlorine is "removed", causing the current flowing between the electrodes to diminish as indicated by the microammeter pointer moving down the scale. Finally, sufficient titrant is added to react with all the chlorine, and no further increase in current is possible. This is called the *end point*.

The amount of chlorine originally present in the test solution is determined by noting the amount of titrant used to attain the end point, and calculating as follows:

Calculation

$$\text{ppm (ng/l) of chlorine} = \frac{\text{ml of titrant} \times 200}{\text{ml of sample}}$$

PROCEDURE

Volume of Sample

It is suggested that, for chlorine residual concentrations of 2 mg/l (ppm) or less, 200 ml be titrated.

For chlorine residual concentrations above this range, a 100-ml sample is more suitable.

It is preferable to use a sample in such a way that not more than 2 ml phenylarsine oxide solution is required.

Filling the Pipet

Make sure the titrant (phenylarsine oxide solution) fills to the engraved 0 level.

Titration of Free Chlorine Residual

1. Fill the solution jar with 200 ml of sample, or 100 ml of sample, as noted under Volume of Sample.
2. Unless the pH of the sample is definitely known to lie between 6.0 and 7.5, add 1 ml pH 7 phosphate buffer solution.
3. Fill the pipet with the titrant (phenylarsine oxide solution) to the engraved 0 level.
4. Titrate by adding phenylarsine oxide solution and observe current changes on the microammeter.
As long as addition of phenylarsine oxide produces a definite decrease in current, free chlorine residual is present.
5. As the *end point* is approached, the response of the microammeter to each increment becomes more sluggish, and *smaller* increments of phenylarsine oxide are added.
6. The end point is just passed when a very small increment of phenylarsine oxide no longer causes a decrease in current.

7. The pipet is then read and the last increment of titrating solution is subtracted from the reading to give a value representing the free chlorine residual.

Titration of Total Chlorine Residual

1. To the sample remaining from the free chlorine titration add exactly 1 ml potassium oxide solution and then 1 ml acetate buffer solution IN THAT ORDER.
2. Titrate with phenylarsine oxide solution to an end point, just as above for the free chlorine residual. It is most convenient *NOT* to refill the pipet but simply to continue the titration after recording the figure for free chlorine residual.
3. After concluding the titration and having found the end point, subtraction of the last increment again gives the amount of titrating solution actually used in reaction with the chlorine.

If the titration was continued without refilling the pipet, this figure represents the total chlorine residual. Subtracting the free chlorine residual from the total gives the combined chlorine residual, or

$$\begin{aligned} \text{Total Chlorine Residual} - \text{Free Chlorine Residual} \\ = \text{Combined Chlorine Residual.} \end{aligned}$$

NOTE: *It is essential to wash the apparatus and sample cell thoroughly to remove iodide ion after this determination, in order to avoid inaccuracies if the titrator is subsequently used for free available chlorine determination.*

4. If desired, the determination of the total chlorine residual and the free chlorine residual may be made on separate samples. If only the value for total chlorine residual is required, it is permissible to treat the sample immediately with 1 ml potassium iodide solution followed by 1 ml acetate buffer solution. The titration is carried out with phenylarsine oxide solution as described above.

INTERPRETATION OF RESULTS

It is unnecessary to use chlorine-demand-free water in making up the reagent solutions. Such small volumes of these solutions are used that the slight chlorine demand of ordinary distilled water has no significance. On the other hand, the destruction of all ammonia contamination contributed by the phosphate salts should be insured through chlorination of the pH 7 buffer solution. Otherwise the ammonia traces often present in phosphate salts may convert significant amounts of free chlorine in the sample to combined chlorine when the pH 7 buffer is added prior to titration for free chlorine. Since the pH 4 buffer is added after that titration, traces of ammonia which might be present in this buffer will cause no similar error. Of course, the pH 7 buffer must be carefully dechlorinated after the ammonia has been destroyed.

MONOCHLORAMINE AND DICHLORAMINE DIFFERENTIATIONS

It is often desirable to differentiate between the monochloramine and dichloramine portion of the combined chlorine residual in a sample solution. This differentiation is accomplished in the following manner:

1. Perform the procedure outlined in PROCEDURE (Titration of Free Chlorine Residual). Note the reading in ppm (free chlorine).
2. Add 4 to 5 drops of potassium iodide, 5% solution to the sample jar. If monochloramine is present, the ammeter pointer will deflect to the right.
3. Titrate to the "end point"; note the reading in ppm.
4. Add 1 dropper of pH 4 buffer solution and add 1 dropper of potassium iodide, 5% solution to the sample jar. If dichloramine is present, the ammeter pointer will again deflect to the right.
5. Titrate to the "end point"; note the reading in ppm.

The difference between the ppm readings obtained in step 1 ("free" chlorine) and step 3, preceding, represents the monochloramine component.

The difference between the ppm readings obtained in step 3 and step 5, preceding, represents the dichloramine component.

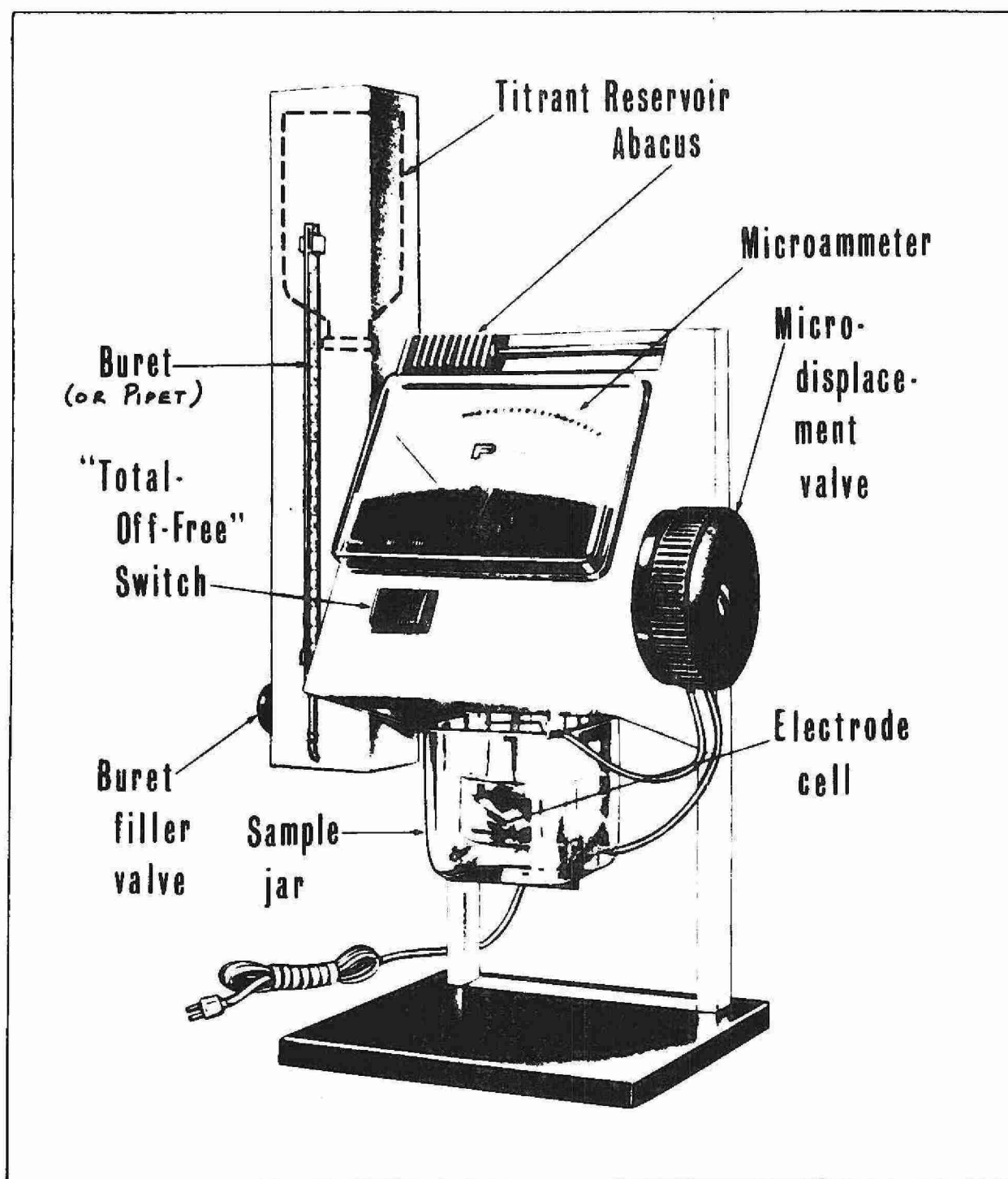


Figure 20-1 Amperometric Titrator

NOTES

APPENDIX A

APPENDIX A

Ontario Water Resources Commission

Division of Sanitary Engineering

CHLORINATION OF POTABLE WATER SUPPLIES

Technical Bulletin 65-W-4

CHLORINATION OF POTABLE WATER SUPPLIES

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CHLORINATION OF POTABLE WATER SUPPLIES

1. 0 INTRODUCTION

1. 1 Purpose of Bulletin

The following information provides a minimum standard of design and operation of chlorination facilities. New installations should meet the criteria as set out in the bulletin and an effort should be made to bring existing facilities up to or above the minimum standard in a reasonable length of time.

1. 2 When Disinfection Required

Treatment by continuous and adequate chlorination is required when the supply is obtained from a surface source; when the supply is exposed to contamination during treatment; when ground water sources are or may become contaminated, as in creviced limestone areas; or where local conditions, such as flooding, indicate the need.

2. 0 EQUIPMENT

2. 1 Capacity

Chlorination equipment shall have a maximum feed capacity at least 50 percent greater than the highest expected dosage required to provide a free chlorine residual. In addition each gas chlorinator not supported by standby units of equal capacity shall have a conversion kit sized to double the capacity of the machine.

2. 2 Chlorinators and Controls

Dependable feed equipment, either of the gas feed or positive displacement solution feed type, may be used for adding chlorine. Automatic proportioning of the chlorine dosage to the rate of flow of the water treated shall be provided at larger plants and at all plants where the rate of flow varies without manual adjustment of pumping rates.

2. 3 Duplicate Equipment

All chlorination equipment at plants providing chlorination to ensure the safety of the supply shall be installed in duplicate, so as to provide standby units for ensuring uninterrupted operation. In addition, spare parts consisting of at least the commonly expendable parts such as glassware, rubber fittings, hose clamps, and gaskets, should be provided for effecting emergency repairs.

For a multi-well supply system requiring chlorination for disinfection, the standby requirement may be covered by one portable unit.

2. 4 Weigh Scales

When gas feed chlorinators are employed, a set of corrosion resistant scales should be made available for weighing the chlorine cylinders serving each operating chlorinator.

2. 5 Hypochlorite Solution

Where a powdered product is used, hypochlorite solutions should be prepared in a separate tank. The solution is allowed to settle so that only a clear liquid is withdrawn to the solution storage tank and to the hypochlorinator.

2. 6 Safety Equipment (Gas application only)

Each plant shall have readily available a self-contained or air-supplied type of respiratory protective equipment. Smaller installations may make arrangements with a local fire department or other agency for the loan of the required equipment on an emergency basis.

When a canister type mask is used in place of a self-contained or air-supplied unit the operators must be made fully aware of its limitations and the location of more adequate equipment.

One respirator shall be immediately available, located in a conspicuous location outside the area of probable contamination.

Protective clothing including gloves, goggles and safety shoes shall be available for persons handling chlorine.

Deluge type safety showers and eye wash fountains shall be available in case of accident.

Preferably weigh scales for 150 pound cylinders shall be recessed in floor.

Safety chains shall be used to retain 150 pound cylinders, either in storage or on weigh scales, in a safe upright position.

2. 7 Building Detail (Gas application only)

Gas chlorine equipment - chlorinators, weigh scales, chlorine cylinders - must be located in an isolated building, room or rooms. In larger installations the storage and scale facilities should be in a room separated from the chlorinators. The construction of the room or rooms should be of fire resistive material and have concrete floors.

Ton cylinders shall be stored on their sides on level racks, between four and eight inches off the grade. Chlorine should not be stored below ground level and the cylinders must be protected from excessive heat, dampness, and mechanical damage.

Areas containing chlorine or chlorinator equipment shall be clearly marked "DANGER! CHLORINE STORAGE" or "DANGER! CHLORINE FEED EQUIPMENT" as applicable.

The exit doors shall be hinged to open outwardly. There shall be two or more exits if the distance of travel to the nearest exit exceeds 15 feet.

Continuous mechanical ventilation at the rate of three air changes per hour shall be provided, or, screened openings to the outdoors shall be provided within six inches of the floor in the ratio of one square foot per 500 square feet of floor area. Similar openings shall be provided in or near the ceiling. The openings shall be distributed to produce the maximum air circulation across the floor. Secondly, provision for emergency mechanical ventilation should be made sufficient to produce 30 air changes an hour taking suction at a maximum of three feet above floor level.

The temperature in the storage and scale room should never be higher and preferably slightly lower than that in the chlorinator room. The gas lines between the scales, chlorinators and injectors should not be located on an outside wall or in a location where low temperatures may be encountered.

2. 8 Testing Equipment

All installations must be equipped with a permanent standard chlorine residual comparator test kit. When free residual chlorination is mandatory an amperometric titrator is also required.

In larger installations, or where poor raw water quality and/or minimum supervision indicates a hazard, a chlorine residual recorder is required. The chlorine residual recorder shall be equipped with a low residual alarm and installed to measure the chlorine residual in the water leaving the plant.

3.0 ROUTINE OPERATION

3.1 Chlorine Residual

For complete water treatment plants which effect both pre- and post-chlorination, or when a minimum of two hours contact time is assured before distribution after the application of chlorine, or where free residual chlorination is practised, or for ground, or protected surface water supplies, the minimum chlorine residual shall be 0.2 p.p.m. For other water supplies the minimum chlorine residual shall be 0.5 p.p.m.

The chlorine residual test is performed on a sample of the plant or pipe line effluent, after it has been held for 15 minutes.

When ground water sources are free from possible contamination and are proved to be bacteriologically safe they may be exempted from chlorination.

As individual circumstances demand the minimum requirements for chlorine residual may be increased.

Free residual chlorination may be made mandatory and is preferred for all supplies that can economically practise it.

A free chlorine residual may be defined as a condition where a minimum of 80 percent of the total available chlorine residual is in the free state.

It is suggested that where possible a chlorine residual be maintained in all active parts of the distribution system.

3.2 Chlorine Application Points

Where possible pre- and post-chlorination shall be practised. When only post-chlorination is possible free residual chlorination should be considered, and a minimum contact time of 15 minutes, before the first possible consumer, must be provided in a pipe line, reservoir, or pressure tank.

3.3 Chlorine Residual Test

The following procedure shall be followed in performing the orthotolidine chlorine residual test.

1. Draw sample of chlorinated water. The tap should be kept running continuously or for a few minutes before taking the sample.
2. Allow sample to stand for 15 minutes to simulate the required minimum contact period.
3. Use 0.5 ml of orthotolidine (O. T.) reagent in 10 ml cells, 0.75 in 15 ml cells, and five ml in 100 ml tubes. Place reagent in testing tube; add sample to required volume; and mix. When the temperature of the sample is less than 68°F bring it to that temperature quickly after mixing with the O. T.
4. A colour comparison is made when the maximum colour develops.
5. The test results are recorded in the plant records and the necessary alteration is made to the chlorine application rate.

The above procedure is satisfactory for determining the total available chlorine residual. When the free residual is required the sample must be near 32°F when the O. T. is added and the colour comparison is made immediately. The orthotolidine-arsenite (O. T. A.) test can also be used to determine the free available chlorine residual.

The accuracy of a chlorine residual recorder shall be checked daily. This is accomplished using either the amperometric titration or orthotolidine colourimetric test procedures. The results of the check are inscribed on the recording chart along with the date and operator's initials, opposite a mark showing the time of the check.

The chlorine residual test must be performed frequently enough to ensure that an adequate chlorine residual is maintained at all times. Such points as raw water quality and a resultant variation in chlorine demand, and changing flow rates must be taken into consideration. When a residual recorder alarm system is used the testing frequency may be reduced.

3.4 Records

Minimum records shall include:

1. daily records of the chlorine used and scale readings,
2. results from all chlorine residual tests,
3. the flow rate and chlorine feed rate at the time of testing,

4. water used and chlorine dosage in p. p. m. on a daily basis,
5. detail on chlorine cylinder changes, orders and chlorine on hand, and
6. monthly and yearly summaries of chlorine consumption and feed rates.

4.0 EMERGENCY OPERATION

Where chlorination is required for disinfection purposes a continuous feed of chlorine must be assured. For this type of service the operating authority shall develop a standby operating procedure to cover emergencies. The procedures developed shall be posted in a prominent location in the plant and all operators shall be made aware of the information thus given.

The emergency information shall include:

1. the order not to pump unchlorinated water to the distribution system,
2. the name, address and telephone number of -
 - (a) senior supervisory personnel,
 - (b) medical officer of health,
 - (c) Ontario Water Resources Commission, Toronto, telephone number - 416-365-1491,
 - (d) chlorinator service company, and
 - (e) chlorine supplier,
3. the order to notify immediately the Ontario Water Resources Commission and the medical officer of health if unchlorinated water is directed to the distribution system,
4. details on emergency chlorination procedures, and
5. a statement on operator responsibility.

When emergency chlorination is provided the minimum chlorine residual in the water leaving the plant shall be 1.0 p. p. m.

When unchlorinated water has been directed to the distribution system, and until direction is obtained from the Ontario Water Resources Commission, the chlorine feed rate shall be increased and a programme of hydrant flushing initiated to provide a minimum chlorine residual of 1.0 p. p. m. in the whole of the distribution system. When increasing the chlorine residual or carrying out an extensive hydrant flushing programme, notify all customers that may be adversely affected.

5.0 ADVERSE BACTERIOLOGICAL RESULTS

When the results from bacteriological samples collected from the distribution system do not meet the requirements of the Ontario Water Resources Commission Drinking Water Objectives, the Ontario Water Resources Commission and the local medical officer of health shall be notified. The Ontario Water Resources Commission will recommend corrective action suited to the individual circumstances. The recommendation may include one or a number of the following procedures:

- (a) the disinfection, for a 24-hour period, of the distribution system with a solution having a starting strength of 50 p. p. m. of available chlorine;
- (b) the initiation of chlorination procedures on an unchlorinated supply;
- (c) an increased chlorine residual requirement along with a distribution system flushing programme;
- (d) the collection of further samples;
- (e) a recommendation to the medical officer of health that a boil water order be issued.

6.0 DISINFECTION OF NEW WORKS

6.1 Preparation

Before disinfection is attempted, all surfaces must be thoroughly cleaned. Pipe lines are flushed with potable water until a turbidity-free water is obtained at all ends. Reservoirs are to be flushed with water and brushed as required, to obtain clean surfaces.

As chlorine is a surface active disinfectant it may not penetrate crevices or particles of debris. Therefore, a thorough cleaning is necessary if the disinfection programme is to be effective.

6.2 Disinfection

Disinfection may be accomplished by one of the following procedures.

1. All surfaces shall be in contact, for a period of 24 hours, with a chlorine solution having a starting strength of 50 p. p. m. available chlorine.

2. All surfaces shall be in contact, for a period of 24 hours, with a chlorine solution of sufficient strength to provide an available chlorine residual of 10 p. p. m. at the end of the contact period.
3. To conserve water and chemical, reservoirs may be disinfected by spraying all surfaces with a chlorine solution having a starting strength of 250 p. p. m. available chlorine. Special protective clothing and self-contained or air-supplied type respiratory must be used by personnel performing the spray procedure.
4. When surface conditions are not ideal, such as will be encountered in used works, special disinfection procedures will be required. This could include the maintenance of a chlorine residual for an extended period of time.

6.3 Testing

After disinfection, and when the chlorine residual in the treated works is at or below the normal operating level, bacteriological samples shall be collected. When a 0.2 p. p. m. or greater available chlorine residual is to be maintained in or after the new works, one set of satisfactory bacteriological results shall be obtained before the system is placed into operation. Otherwise, a minimum of two and preferably three consecutive sets of coliform free results shall be obtained before the works are used.

APPENDIX B



ONTARIO
DEPARTMENT OF LABOUR
ENGINEERING SERVICES BRANCH

ENGINEERING
DATA SHEET NO. 5-3

STORAGE AND USE OF CHLORINE

Introduction

Chlorine has wide use in industry. 150 lb. cylinders are commonly used. Where usage exceeds 150 lbs. daily, one-ton containers have been introduced to minimize handling.

Properties

Chlorine liquid has a specific gravity of 1.47 (water = 1)

Chlorine gas has a density of 2.49 (air = 1)

One volume of liquid chlorine gives off 456.8 volumes of gaseous chlorine at 32°F and 1 atmosphere pressure.

One pound of liquid chlorine is equivalent to 4.98 cubic feet of gaseous chlorine at 32°F and 1 atmosphere pressure.

Dry chlorine does not corrode steel or common metals at ordinary temperatures. In the presence of moisture, hydrochloric acid is formed causing corrosion.

Characteristics

Chlorine is non inflammable, and is a powerful respiratory irritant.

1. Location

- (a) Storage should preferably be in an isolated building or in a room without direct access to a factory area. Construction should be of fire-resistive material and the building or room should have concrete floors and good drainage.
- (b) Ton containers shall be stored on their sides on level racks, e.g. parallel "I" beams. There should not be less than 4 in. and not more than 8 in. air space between the container and grade.
- (c) Chlorine should not be stored below ground level.
- (d) Chlorine should not be stored with combustible materials.

- (e) The container shall be protected against excessive external heat sources, dampness and mechanical damage. Outside storage should be sheltered from the direct rays of the sun.
- (f) Separate storage space shall be provided for full and empty containers.
- (g) Storage areas shall not be located in areas where escaping gas could enter a ventilating system.
- (h) Chlorine storage areas shall be clearly marked "Danger! Chlorine Storage!"
- (i) The scale room should be adjacent to the storage area and be of fire resistive construction.

2. Exits

The exit doors shall be hinged to open outwardly. There shall be two or more exits if the distance of travel to an exit exceeds 15 ft.

The distance of travel to the nearest of two or more exits shall not exceed 75 ft.

3. Ventilation

- (a) Continuous mechanical ventilation at the rate of 3 air changes per hour shall be provided, or, screened openings to the outdoors shall be provided within 6 inches of the floor in the ratio of 1 sq. ft. per 500 sq. ft. of floor area. Similar openings shall be provided in or near the ceiling. The openings shall be distributed to produce the maximum air circulation across the floor.
- (b) Provision for emergency mechanical ventilation should be made sufficient to produce 30 air changes an hour taking suction at a maximum of 3'-0" above floor level.

4. Protective Equipment

- (a) Emergency canister gas masks of a type approved for chlorine service by

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ENGINEERING SERVICES BRANCH,

8 YORK ST.,

TORONTO 1,

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the United States Bureau of Mines shall be readily available where chlorine is being stored or used. The gas masks shall be kept in dust-tight cabinets and the cabinets locked in a conspicuous location outside the area of probable contamination.

- (b) Only self-contained or air-supplied types of respiratory protective equipment shall be used where the chlorine concentration may be above 1 per cent (10,000 p.p.m.). Gas masks are of no use in these cases.
- (c) Protective goggles, aprons, gloves and safety shoes shall be available for persons loading, storing, or handling chlorine.
- (d) Deluge type safety showers and eye wash fountains shall be available in case of accident. These shall be located as near as possible but outside the area of probable contamination.

5. Chlorine Leaks

A plan of action shall be prepared to deal with emergency leaks. A chlorine tool kit recommended by the supplier shall be available.

6. First-Aid

Remove the affected person from the contaminated area. Keep him warm and quiet. If the victim is conscious, do everything possible to discourage coughing. Oxygen is of great value. Even in mild cases, inhalation of oxygen relieves chest irritation. In severe exposure cases, oxygen should be administered until the victim is able to breathe easily. Contaminated clothing should be removed and contaminated body areas flushed with water. If breathing seems to have stopped or has ceased, apply artificial respiration without delay along with oxygen. The services of a physician should be obtained as quickly as possible.

7. Chlorine Disposal

Chlorine may be absorbed in solutions of caustic soda, soda ash, or hydrated lime. A solution of caustic soda absorbs chlorine most readily.

RECOMMENDED SOLUTIONS FOR ABSORBING CHLORINE (ONE-TON CONTAINER)	
ABSORBING CHEMICAL	WATER
Caustic Soda — 2500 lb.	800 gallons.
Soda Ash — 6000 lb.	2000 gallons
Hydrated Lime — 2500 lb.	2500 gallons

APPENDIX C

APPENDIX C

PERSONAL HYGIENE

It is in the interest of your health and the health of your family that this list of do's and don'ts for personal hygienic habits are made. Use it, don't abuse it!

1. Never eat your lunch or put anything into your mouth without first washing your hands.
2. Refrain from smoking while working in tanks, on pumps, trucks, filters etc. Remember, you inhale or ingest the filth that collects on the cigarette from dirty hands. Save your smoking time for lunch hours or at home.
3. A good policy is never put your hands above your collar when working on any plant equipment.
4. Don't wear your coveralls or rubber boots to the dining area.
5. Always wear your rubber boots when working in tanks, around sludge, washing down etc. Don't wear your street shoes.
6. Keep your street shoes in your locker, remember that what your shoes pick up at the plant they will leave on the floor of your home.
7. Don't wear your coveralls or rubber boots in your car or home.
8. Have a complete change of clothing to wear when going home.
9. Always clean any equipment such as safety belts, harness, face masks, gloves, etc., after using. You or someone else may want to use it again.
10. Always wear rubber or plastic coated gloves when cleaning out pumps, handling hoses or when working anywhere around the plant.
11. Avoid putting on the gloves when your hands are dirty, wash first.
12. Wash with plenty of water or take a shower immediately after being splashed with sludge, or any chemical, don't delay.
13. Don't just wash your hands before going home, wash your face thoroughly too, there is more of your face to carry germs than there is of your hands.
14. Wear a hat when working around sludge tanks, filters, or cleaning out grit or other channels, don't go home with your head resembling a mop that just wiped up the floor around a cleaned out pump.
15. Keep your fingernails cut short and clean, they are excellent carrying places for dirt and germs.

APPENDIX D

APPENDIX D
PLANT LABORATORY

Essential Items Required

1. Appropriate signs and notices
2. Protective clothing
3. Marked refuse containers
4. First Aid kits

Operating Safety Instructions

1. Laboratory glassware must not be used for food or any other use than what was intended.
2. All bottles and containers must be clearly marked so that the materials they contain can be clearly identified.
3. Suction bulbs will be used on all pipettes.
4. Access areas around shut-off valves and top areas of the sink and counter must be clear of unused equipment at all times.
5. Oil or grease must not be used as lubricants when making glass-to-hose connections on any laboratory equipment. Use only water or water-soluble lubricant jellies.
6. Gloves should be worn when making glass-to-hose connections.
7. All glassware must be kept clean by using detergent solutions for general cleaning or by soaking the glassware when necessary in a cleaning solution of sodium dichromate and concentrated sulphuric acid.
8. Chemicals that cannot be identified must be disposed of.

Suggested methods of disposal - dilution, incineration, dumping, etc. This is to be done only by someone who understands the risk involved.

9. A thorough knowledge of first aid for dealing with accidents involving chemicals, gases, glass cuts, infections and burns of all types is essential.
10. Bottles containing hazardous liquids must not be stored in high places where it is necessary to climb up or reach above the head to get them. Store them in lower shelves by themselves.



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Ontario Water Resources Co

Basic gas

chlorination apwk

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